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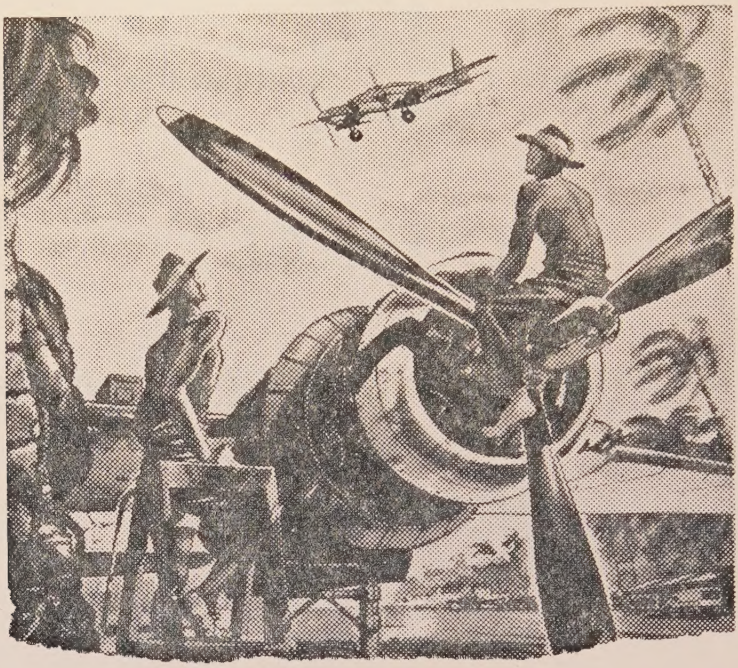

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The Management of Salt Lands in Western Australia.

L. J. H. Teakle and G. H. Burvill.

The Salt Problem in Western Australia.

Soil salinity—the occurrence of excessive amounts of water soluble salts in soils—is a factor in agriculture and agricultural development in many parts of the world. It usually becomes a problem in areas of low rainfall, or where the rainfall per wet day is low. In Australia, the manifestation is rare where the average rainfall per wet day exceeds 30 points. Of course, marshy areas, where saline waters occur near the surface and drainage is restricted, also suffer from soil salinity more or less irrespective of the rainfall.

Evidence of soil salinity is observed in all States of Australia, but apart from development in irrigation areas, is of minor importance, except in Western Australia, where areas affected by salinity, or "magnesia," as it is often wrongly called, are common throughout the wheatbelt and small patches may be affected even in the wetter districts near this coast where drainage is imperfect. Considerable attention has been given to soil salinity problems in the Western Australian wheatbelt, but no major reclamation projects have yet been organised.

It is very doubtful whether any large-scale engineering works for drainage would be possible on a sound economic basis, but something is being done, and much more can be done, on a small scale on individual farms. In fact, many farmers have attempted reclamation with some degree of success in certain instances. Examples will be given at the end of this article.

Manifestation of Soil Salinity in Western Australia.

In Western Australia soil salinity occurs under two distinct sets of conditions.

The first is associated with a high concentration of salt in the soils under virgin conditions. The drier parts of the eastern and south-eastern wheatbelt are most severely affected. Agricultural settlement in the Lake Brown, Southern Cross, Lake King, Lake Camm and Salmon Gums districts has suffered on account of soil salinity of this type.

Areas of low rainfall near the coast, e.g., Salmon Gums, where the rainfall contains relatively large amounts of salt, are most liable to soil salinity, and the heavy soils are most severely affected. Soil types containing most salt are those associated with morrel (*Eucalyptus longicornis*) and Kondinin blackbutt (*E. Kon-*

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dininensis), and clays associated with gimlet and certain types of mallee, in the south-eastern areas. After clearing, there is a danger from the rise of salt from the subsoil, with resultant decline in crop yields and the growth of feed, unless a suitable management programme is instituted.

The second set of conditions associated with the encroachment of soil salinity involves the rise of the salt ground water or the development of seepages of brackish water. There are many instances, in the large and small valleys of the agricultural areas, where the salt water table has risen from depths of 20 feet or more, when the surrounding country was virgin, to 3-6 feet, under the present agricultural development. In many cases, timber and scrub left in the valleys to keep down salt has been killed by encroachment of soil salinity associated with the rise of the ground water, and bare areas, crusted with salt, may show where the valleys have been cleared. These bare areas suffer severe damage from soil erosion, which adds to the seriousness of the condition.

It has been observed that salt encroachment, and consequent damage to the soil, is generally serious where the ground water is closer than 5 or 6 feet from the surface. The rise in the water level is due to the clearing of the timber over large areas. The rain which soaks into the soil was absorbed and dissipated by the scrub and timber under virgin conditions, and equilibrium had been established. After clearing, much of the rain which soaks into the soil percolates to depths, and in the absence of deep rooted timbers to absorb it, contributes to the ground water which is rising throughout the developed agricultural areas. Often the ground water is brackish or saline, and when it approaches the surface, soil salinity problems develop.

The manifestation of soil salinity in Western Australia is increasing, particularly in the wetter parts of the wheatbelt, where this rise in the water table occurs most generally. There are no reliable estimates of the area of farmlands affected. Twenty years ago, the Royal Society made enquiries, and concluded that about 3 per cent. of our agricultural lands were affected. General observations suggest that at the present time 5 per cent. of lands under cultivation may suffer more or less from salt encroachment. The encroachment is forcing many farmers to adjust their activities to minimise the damage from soil salinity. However, in some districts where the topography of the land is conducive to a general rise in the water table, the damage is much more severe, and whole farms have been rendered practically useless. Instances are the Dongolocking Flats, Moulyinning, and parts of the Wongoondy Estate, between Mullewa and Mingenew. In some of the older districts encroachment on some farms appears to have passed its peak, and slow reclamation of the affected areas is observed.

A serious aftermath of salt encroachment is soil erosion. The salt kills the vegetation—grasses, scrub and trees—and the soil is exposed to the elements. Wind action combines with water to remove the surface. Then follows accelerated water erosion with the formation of gutters and gullies. In many cases the control of erosion on salty patches seems even more difficult than the reduction of the salt effect.

Experimental Work.

Officers of the Department of Agriculture have made observations on the management of salt lands for many years, and conducted a number of experiments bearing on the problem. Reports have been published in this Journal. Three aspects of the problem are:—

1. *The promotion of water absorption and drainage* to accelerate the removal of salt. An experiment is in progress at the Avondale Research Station on a small area where the water table is very near the surface—brackish water

is generally less than 2 feet down. Such a shallow water table magnifies the difficulties of reclamation, and as yet, little progress has resulted from the drainage and cultural treatments under test.

A number of farmers, on their own initiative, and as a result of the recommendations of Departmental officers, have ploughed drains through saline areas, and many of these are satisfied that reduction in salinity has resulted.

With respect to drainage in the reduction of salt encroachment, experimental work is planned in association with the Public Works Department, in order to determine the practicability of works of greater magnitude than may be appropriate for a private farm.

At the Merredin Research Station an experiment with soil in tanks has been conducted, and demonstrates the effect of a sandy surface layer in promoting absorption of rain water and the washing out of salt. It has been found that the salt is displaced into the deeper layers of the subsoil, and reclamation effected. Any other surface cover, such as rotting straw and farmyard manure, may be expected to favour reclamation. Similarly, a cultivated surface will more readily absorb the rain water than a bare, flat one, and ploughing or scarifying in autumn has a good effect.

2. *The establishment of salt tolerant plants.* During the last decade, work has been carried out on the Chapman and Salmon Gums Research Stations and on private farms at Moora, Damboring and Calcarra, on the establishment of various types of plants more or less tolerant to salt. Many species were tried, but only a few proved of much value. Of the grasses, Wimmera rye grass has been most successful. Barley grass is useful, and a false rye grass (*Pholiurus incurvus*) proved very tolerant in many places, but does not seem to compete satisfactorily with Wimmera rye grass. At Calcarra a perennial wheat grass (*Agropyron sp.*), obtained from Dr. Hansen in America by Mr. J. Truman, has grown well on moist salty soil in an enclosure. This grass is undoubtedly very tolerant of salt, but has not yet been tried under field conditions. A type of paspalum (*Paspalum vaginatum*), obtained from Mr. C. Bleechmore of Boyup Brook, is under test on saline soils at the Chapman Research Station.

Various salt bushes have been tried, but have proved of little practical value in most instances. Trailing salt bush (*Atriplex semibaccatum*) is probably the best of the species tried, and has shown evidence of some value on the heavy soils of the Salmon Gums Research Station, when grown in association with Wimmera rye grass. Mr. L. D. Edwards, of Goomalling, is satisfied with the growth of a salt bush (*Atriplex paludosa*) obtained from the Cowcowing Lakes. Tamarisk (*Tamarix gallica*), which is reported to be salt tolerant and of value for stock feed, is being tried on saline country at Yericoin.

3. *The depth and composition of the ground water.* Evidence from wells has suggested that in Western Australia the salinity of the ground waters commonly increases after the clearing of the country. The water may become unsuitable for stock. This is also associated with the rise of the water level. After a period of years, the salinity reaches a peak, and subsequently improvement takes place and the wells may again become useful for domestic purposes.

Commencing in 1939, observations have been made on the depth of the water level and the salinity of the ground water, by means of test wells and bores on farms at Moora, Damboring, Piawaning, Cadoux, North Cunderdin and Lake Muir. This investigation is a long-range project, designed to provide data on the seasonal changes in the composition and the trends over years, in relation to salt encroachment. Samples are taken at the end of the winter and at the end of the summer each year, and are analysed for salt content. During the six years

that the observations have been made, none of the sites under observation has given definite evidence of increase or decrease in salinity. It is expected that fifteen or twenty years may elapse before substantial changes occur at some sites, and much longer periods are likely to be involved at others.

The Management of Salty Soils.

It is commonly held by farmers that cultivation of salt liable country promotes the spread of salt in the soil. This is not so. The spread is due to clearing of the higher country adjacent, which is responsible for the rise in the water level. Cultivation at the correct time generally retards the encroachment. Farmers who assiduously avoid cultivation near salty patches are not restricting the spread of soil salinity. If anything, they are unwittingly neglecting a measure important to reclamation.

The objective in the treatment of saline soils is the establishment of a vegetation cover, whether it be crop, pasture or volunteer scrub. Leaving the land untouched is most unsatisfactory, as the bare patches associated with soil salinity do not absorb moisture readily. The salt remains near the surface, seeds are readily blown away, and seedlings which do start are killed by the salt. Furthermore, damage from erosion is commonly severe. If left alone, barley grass and other salt tolerant plants grow first on sand-drifts, around obstructions and in shallow furrows, and reclamation is very slow. Appropriate cultivation will lead to the washing out of salt from the surface by the rains and thus promote the establishment of various types of plants, particularly those more or less tolerant of salinity.

To be favourable for the establishment of a vegetation cover, the surface soil needs to be appropriately treated to form a cloddy or corrugated surface—not flat and unreceptive. This is accomplished by cultivation. Cultivation in a suitable crop rotation is desirable in all cases, except where the degree of soil salinity is so severe that no practical treatment can be effective. Preferably, the land should be ploughed in the autumn, about the time of the first rains, so that the salty crust is buried. The ploughed surface is in a condition to absorb the rain and the water soaking in will wash the salt into the subsoil. The soil is then in a suitable condition for planting of a crop or grasses.

Barley is probably the most salt tolerant of the cereals, but oats may be used with every prospect of success. Seeds such as Wimmera rye grass and barley grass may be sown to provide a dense grass cover in the years when the land will not be under crop. Over small areas, farmyard manure is useful, and gives the crop or grass a good start. A straw mulch will serve a similar purpose, after rotting down. It should be emphasised that planting should be delayed until after the first good rains have washed the salt out of the surface soil.

Fallowing is not advisable, as salt tends to rise to the surface from the moist subsoil over the summer months. Salt in the soil breaks down the tilth, and flat patches form which are ideal for surface concentration by capillarity. Furthermore, fallowing destroys weeds, and it is desirable that salt tolerant plants be encouraged on such soils to maintain a cover, as far as possible, throughout the year.

This type of cultural treatment is advisable as long as the salt problem is moderate. When the condition is too severe, as is the case in some valleys, for instance, where samphire has established, or where saline water comes too close to the surface, little can be done, economically, to handle the country. Treatment may be reduced to measures designed to protect the soil from the ravages of soil erosion.

Improvement of drainage should be promoted in all portions of an area affected by salt. Shallow drains with a small fall, so that scouring will not occur, may be put in to carry off excess water, and to tap brackish springs on the slopes which feed the ground water lower down. When cultivating, the direction of the ploughing should be designed to promote drainage over the subsoil into the outlet drains. Drainage by subsoiling with a dam sinking plough or other suitable implement is recommended.

At various times there have been proposals for the institution of large-scale drainage works to promote the reclamation of saline lands along certain of the salt-lake systems in the main valleys of the wheatbelt. These salt lakes represent the present drainage of the country, but surface water flows at very infrequent intervals. Occasionally water from Lake Ballard, near Menzies, comes down through Lake Deborah and Lake Brown to Baandee and Quairading, to join the upper Avon near Beverley. Apparently in bygone ages the climate was much wetter and these channels probably carried considerable quantities of water from the inland areas. While a deep channel through such systems would facilitate drainage, the effect on the water level of the adjoining agricultural lands would be extremely small and the cost out of proportion to material benefit. It seems likely that drainage will be of practical value, and probably economic only where moderate salinity has developed and subsidiary valleys are involved.

Experiences in Reclamation.

Over the last 15 years, farming has been conducted on saline soils of a heavy type on a portion of the Salmon Gums Research Station. This type of country had proved generally unsatisfactory for wheat growing under the usual types of wheatbelt management, and experiments were laid down to determine the possibility of devising improved methods for its utilisation. The soils involved in this experimental work are heavy clays with crabholes. No water table occurs within many feet of the surface and crop yields were affected by the salinity of the subsoil and the development of bare areas, owing to surface accumulation in patches.

The success of Wimmera rye grass, which is very salt tolerant, on this type of country at Salmon Gums, enabled a rotation to be instituted, involving the production of a greatly improved pasture and a limited amount of cereal cropping. This system has proved reasonably satisfactory, and land which earlier was deemed of little agricultural value is now carrying good Wimmera rye grass pastures for stock raising under our wheatbelt conditions. The returns have been sufficiently satisfactory to warrant the development of further areas of this type of country on the Research Station.

A number of farmers in Western Australia have attempted the reclamation of salt affected areas, and some report encouraging progress from the application of the principles discussed above.

Mr. J. Truman, of Calcarra, had abandoned a moderately saline flat along a salt creek through his property, as he feared that further cultivation would result in increased salt encroachment. On advice, he ploughed this flat in autumn, and after the first good rains, sowed oats. Apart from a few bare and thin patches associated with areas of imperfect reclamation, the growth was generally splendid, and Mr. Truman got most of his hay for the year from this salt flat.

In the working of salt affected country, Mr. Whitehead, of Hines Hill, has been very satisfied with the result obtained by tearing up the ground to a depth of 6 to 8 inches by means of a mould-board plough, from which the mould-boards

had been removed. The land had been cultivated to a shallow depth for a number of years with a scarifier, and a slight hardpan, which restricted the absorption of water, had developed. Deeper ploughing broke this pan and allowed the absorption of water and the removal of the salt. As a result, good crops were obtained and the salt effects were very much reduced.

Mr. L. D. Anderson, of Jennacubbine, has written at length of satisfactory experiences in the reclamation of salty country on his property "Brookside" farm. The method adopted by Mr. Anderson involves—

1. Judicious cultivation to promote absorption of water and to enable the establishment of grasses or crop after sufficient rains have fallen to wash out the salt. Salt tolerant plants are not necessary if the washing out is successful.

2. The institution of drainage at the source of the salt patch to tap the seepage water which may be contributing to the encroachment of salt and to remove the accumulation of salt.

Plants which have given satisfactory results include barley grass, Wimmera rye grass (which needs attention), subterranean clover, Mexican spinach, Sudan grass, and cereals. A rigid tyne combine or scarifier is preferred to ploughing by Mr. Anderson. Drainage is effected by means of a dam plough with the skid removed, so that the share sinks to a depth of about 18 inches. The drains are ploughed following the natural fall of the country to the lowest point, and are put in every two or three yards in all cases.

As the primary object is to establish a cover, stock should be very carefully managed. Mr. Anderson points out that it is important that they be kept off while the soil is moist, as the trampling will promote capilliary action and the deposition of salt on the surface.

In the same district, Mr. L. D. Edwards, of Goomalling, has been growing a salt bush (*Atriplex paludosa*) obtained from Lake Cowcowing. He finds that the salt bush does not propagate readily from artificially sown seeds, but many seedlings come up around the established bushes. The seedlings are planted on the area to be reclaimed. Mr. Edwards ploughs fairly deep drains through the salty areas, and puts in shallow feeder drains with a single furrow plough.

Mr. S. C. Dall, of Quairading, has found it possible to cultivate moderately salt-affected country for cereals by avoiding fallowing and sowing on land ploughed up in the autumn, after the first rains have washed the salt out of the surface.

Shallow surface drains associated with the establishment of Wimmera rye grass are proving satisfactory on Mr. Max Duggan's property, Yericoin, where a salt creek has developed near his homestead.

CONCLUSION.

The problem of soil salinity in Western Australia is increasing, and much more research is needed to discover improved methods of management and methods of application of the known principles of reclamation.

There are areas of salty country which are not worth considering for reclamation. These are usually in broad flats and where the salinity is excessive over considerable areas. The conditions with respect to drainage and the occurrence of saline ground water at shallow depths render reclamation impracticable. On such areas, any timber left at time of clearing has been killed, grass becomes very sparse and the place of the original vegetation is often taken by samphire.

On the other hand, there are considerable areas where the position is far from hopeless. Where the country is moderately affected by salt, reclamation may be attempted with a reasonable prospect of success and promise that, with proper management, the land may be maintained in a condition suitable for the growing of crops and pastures. A number of farmers who have applied the principles discussed in this article have been well satisfied with the results.

Fortunately, the principles of reclamation are simple. They involve drainage, washing out of the salt, and maintaining a surface cover to protect the soil surface from further damage by erosion and concentration of salt. It is probable that there will be little need for expensive equipment or the introduction of special new crops, in order to effect reclamation. Investigation is necessary to determine how and when to cultivate the salty land for best results, how best to put in a cheap drainage system and to establish a crop or pasture, and the economics of the operation. Successful application of these reclamation measures will bring into production areas of moderately salty land on established farms, restrict spread of salt, and reduce further deterioration associated with soil erosion.

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The Soils of the 3,500 *Farms Scheme Area, W.A.,* L. J. H. Teakle: Jour. Dept. Agric., West. Aust., xvi., 202-230, 1939. Leaflet 596.

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The Mechanisation of Fodder Conservation.

A. J. MILLINGTON.

THE efficient operation of the farm as a production unit requires suitable machinery to give a satisfactory output per man-hour of labour, and Australian farmers and engineers have been notably successful in developing mechanical grain harvesting equipment well suited to our climatic conditions. However, current methods of conserving bulky fodders such as cereal or grass hays are relatively inefficient when compared with those employed to harvest grain. The high manual labour requirement of current methods causes considerable delays in stacking, resulting frequently in an inferior as well as an expensive fodder reserve.

But for the interruption caused by the war, farmers would have seen already something of the machinery designed not only to reduce the cost of handling hay and silage, but also to enable the conservation of a better quality fodder. Two broad approaches have been made and these may be classed as—

(i) Chopped hay or silage;

(ii) Baled hay.

In each instance the procedure usually involves mowing and windrowing with a side delivery rake. Where wet weather is likely to interfere with curing, a mower-crusher to break coarse stems is recommended. This ensures uniform curing of stems and leaves.

MECHANISED ENSILING.

Silage making may provide for the direct transference of the material from the cutting bar to a towed trailer for transport to the silo. This arrangement is used in the English equipment shown in Figure I.

Fig. I.—English silage-making equipment.

The degree of wilting desirable prior to ensiling will vary from one material to another, but windrowing as soon after cutting as possible ensures uniform drying. Silage is coarsely chopped and blown into a towed trailer by the American machine shown in Figure II. As the feed to the chopper is automatic, the labour requirement is very low and provided the quality of the material being ensiled is satisfactory, a highly nutritious silage can be obtained at a very low cost, particularly with the pit silo. In years of plenty, hundreds of thousands of tons of natural pasture are allowed to run to seed on wheat-belt farms. Since the nutritional value depreciates rapidly with approaching maturity, most of this material is wasted. Silage making is probably also the most economical method of controlling weeds such as the mustards and wild oats.

The equipment shown in Figure II can be used for chopping hay for storage in suitable bins.

Fig. II.—American silage-making machine.

BALED HAY.

The principal advantages of baled over chopped hay are convenience of handling when feeding and ease of storage. Baled hay usually requires only one-fifth the space necessary for loose or sheaf hay and if sheds are not available, it can be easily stacked and roofed in the field.

Fig. III.—Portable hay-baler with pick-up attachment.

Figure III shows a machine tested in this State several years ago. It is a combination of an ordinary hay baler made portable and a pick-up attachment. A crew of three and a tractor driver are required to operate it. Two of the crew are required for wiring the bales and the third for regulating the flow of material into the press.

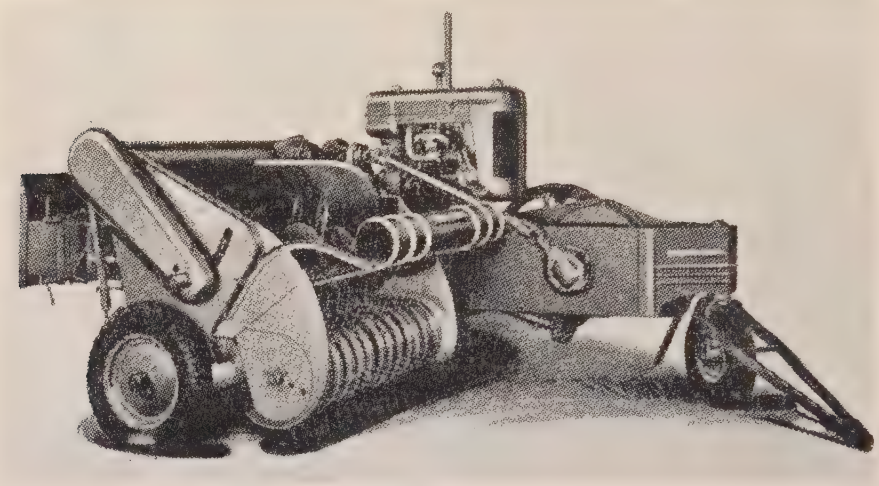


Fig. IV.—Recent American hay-baling machine.

More recent American machines, Figures IV and V, automatically tie the bales with special twine, so that given an experienced tractor driver and uniform windrows, no crew is required. The bales may be loaded direct onto a towed trailer, or, as is usually the case with contract baling, left in the field. Mechanical elevators facilitate the handling of the bales which can be adjusted to weigh from to half to one hundred-weight. The output of the machine shown in Figure IV is 4-5 tons per hour.

Fig. V.—American hay-baling machine in operation.

Overseas, where wet weather frequently interferes with hay-making, it is customary to bale relatively moist material. Insufficiently dried material must be baled loosely in small bales to avoid overheating and deterioration in quality. Such bales are loose for handling after the material has dried out.

The desirable specifications for baling given by an American authority are a moisture content of 20-25 per cent. and a bale density of 8-10 lbs. per cubic foot. This gives a hay of good colour and bales which will withstand a reason-

able amount of handling without falling apart. Baling too dry gives a chaffy hay. The moisture content of cereals at the optimum stage for cutting in Western Australia is about 60 per cent. and for cured hay 8 per cent.

The use of a side delivery rake is essential for the successful operation of the pick-up equipment as a uniform, coherent windrow is essential.

SUMMARY.

There is every indication that the immediate post war years will produce machines capable of eliminating most of the drudgery associated with hay and silage making.

The cost of these machines should not be beyond the means of the average farmer, particularly if he is prepared to contract operate with his neighbours.

By speeding the operation of fodder conservation they will result in a better quality as well as a cheaper reserve.

Notes on Storage of Potatoes at Manjimup.

A. Sharp, Tobacco Adviser.

THE 1944-45 season has seen an enormous increase in potato production in the Manjimup-Pemberton area. The extent of the increase in the spring planted crop can be gauged from the following production figures supplied by the local potato agents:—

	Manjimup. Tons.	Pemberton. Tons (approx.).	Total. Tons (approx.).
1943-44	145	200	345
1944-45	2,640	1,022	3,662

In response to the appeal by the Commonwealth Government for increased potato production—an appeal backed by a guaranteed price of £12 10s. per ton for grade 1 potatoes—a number of farmers who previously had not included potato growing in their activities entered the industry, while those who had previously grown increased their area under crop. This, combined with a very favourable growing season and the fact that supplies of high quality disease-free seed were available, resulted in the phenomenal increase just noted.

Some misgivings were entertained by local agents and growers as to the possibility of disposing of such a large crop as rapidly as it could be dug, particularly in view of the introduction of the mechanical potato digger.

Until the end of January, however, no serious trouble was experienced. During January an experimental shipment was exported to Ceylon. This shipment was later reported to have arrived in excellent condition with only 5 per cent. wastage having occurred. As a result, further substantial shipments have been ordered and despatched there.

Early in February, shipping difficulties caused a hold-up in deliveries and it was decided to store several hundred tons at Manjimup until the position could be rectified. Permission was obtained from the Forests Department to stack the potatoes under the pine trees at the Department's Arboretum at Manjimup.

Stacking commenced on 6th February. The potatoes were carted from farms by motor truck, generally in loads of about five tons. Following a request from the Officer-in-Charge of the Potato Branch (Mr. E. T. Morgan) on arrival at the stack each load was inspected by the writer, and, if the sample was up to Grade 1 standard it became the property of the Australian Potato Committee. The bags were then placed in the stack and the grower's responsibility for them ceased. The stack was built eight bags high.

Carting and stacking went on continuously until 6th March, by which time a total of 970 tons had been stored. During the latter part of this period derris dust was blown into the mouth of each bag in order to prevent infestation with potato moth which was becoming troublesome in the district.

It is satisfactory to be able to record that only a small proportion of the potatoes delivered at the stack had to be rejected. Out of the total of 970 tons, only 10 loads totalling approximately 38 tons had to be set aside for regrading. Of this quantity, approximately 20 tons were rejected for breakdown, 13 tons for moth infestation and five tons for scab. It was noted that while one or two cases of breakdown were probably due to sunburn, the great majority of tubers showing this condition had been stabbed with the fork when being dug. The chief criticism of the grading as a whole is that many growers include fork damaged potatoes in the first grade. This is a matter which growers will be well advised to rectify in future. Some growers argue that a fork damaged potato will keep just as well as an undamaged one. This is definitely not the case. A large number of bags showing wet spots were opened by the writer during the inspections and it was found that in the great majority of cases the trouble originated in a forked tuber. In view of the difficulties experienced in the way of labour shortage, hot weather and potato moth during February and March, growers are to be commended on the quality of the sample delivered.

As far as the writer is aware, this is the first occasion on which large scale storage of potatoes has been attempted in this State other than in artificial cool storage. No data was available therefore, regarding the amount of wastage which might be expected. Many extremely pessimistic opinions were expressed in Manjimup when the project was announced, estimates varying anything from 10 per cent. to 100 per cent. loss. The writer therefore decided to maintain close observation on the stack with a view to determining the length of time elapsing before any large scale breakdown should occur, possible cause of such breakdown, and so on. At the suggestion of the Assistant Deputy Controller of Potatoes (Mr. B. H. Burvill) thermometers were placed over and inside the stack and temperatures were recorded as opportunity offered. Unfortunately, owing to pressure of work at the Tobacco Research Station, the writer was unable to keep as complete records as was desirable. The following table gives the figures obtained:—

No. 1 thermometer was hung on a pine tree about two feet above the top of the first stack.

No. 2 was lowered between the bags in the middle of the first stack to be built and was left about one foot above ground level.

No. 3 was placed in a similar position to No. 2 in the second stack.

No. 4 was the Forests Department's thermometer situated about 100 yards away and hung in a standard Stevenson screen.

All readings are in degrees Fahrenheit.

THERMOMETER READINGS.

Date.	Time.	No. 1.	No. 2.	No. 3.	No. 4.
Feb. 23 ...	3 p.m.	67	65	...	69
24 ...	10 a.m.	61	61	...	64
24 ...	2 p.m.	66	63	...	69
26 ...	3·30 p.m.	82	61	63	83
27 ...	9·30 a.m.	72	64	63	74
27 ...	8 p.m.	86	64	64	89
28 ...	9 a.m.	74	64	64	77·5
28 ...	2·30 p.m.	78	64	64	76·5
Mar. 1 ...	9·30 a.m.	67	64	63	67·5
1 ...	2 p.m.	71	65	65	74
2 ...	4·45 a.m.	61	63	...	...
2 ...	11·30 a.m. ...	63	64	63	64
2 ...	4 p.m.	68	64	...	...
3 ...	9·20 a.m.	60	62	62	62·5
5 ...	3 p.m.	78	67	67	77·5
6 ...	9·20 a.m.	61	61	60	60

It will be noted that no extremely high shade temperatures were recorded during the period covered, 89° being the highest under the Stevenson screen. Generally, the temperature under the pines was from 1° to 3° lower than in the screen. The difference between the temperature under the pines and that in the sun, however, was very marked. Even on the hottest days it was delightfully cool and pleasant under the trees where the stacks were built.

Temperatures recorded by the thermometer suspended above the stack varied from 60° to 86°, and, as would be expected, were lowest in the early mornings and rose to a maximum during the afternoons. The temperatures within the stacks, however, remained remarkably uniform day and night, varying only from 61° to 65°. On only one occasion did the internal temperature rise above the latter figure, and then only to 67°.

By 7th March no signs of deterioration were visible in the bags on the top or outside of the stacks, and on that date a number of bags were removed from various places inside the stacks and their contents examined. It was then found that only an odd bag here and there showed a wet spot due to one or two tubers breaking down, but the loss thus caused was negligible. The only exception was a consignment from a crop which had been grown under irrigation. Some bags in this consignment had broken down badly and a few were a complete loss. It would thus appear that potatoes grown locally under conditions of natural moisture have considerably better keeping qualities than those grown under irrigation. It was noted also that potato moth larvae had made little or no progress during the storage period.

Removal of potatoes from the stack was begun on 14th March. It was then found that a very small proportion of the bags showed wet spots, and these, on being regraded, were generally found to contain only two or three potatoes unfit for use. Carting from the stack continued until 27th April. Towards the end of that period, wastage increased very slightly perhaps, but at no time could it be regarded as excessive.

Final figures of tonnage obtained from the stack are not available at the time of writing, but it is understood that the number of bags taken from the stack, including those regraded, is 180 bags less than the number placed in it, a loss of

approximately 11¼ tons, or a little over 1 per cent. In addition, of course, there will be a small loss in weight due to the evaporation of moisture from the tubers during storage.

This result can be regarded as remarkably satisfactory, far more so in fact, than anyone had previously dared to hope. The knowledge that locally grown spring crop potatoes can be stored in the open under shade, without the expense of artificial cool storage, for a period of at least two months during the hottest part of the year, without undue deterioration is likely to prove useful in the future.

Experiments With Phosphatic Fertilisers, 1943 and 1944.

L. J. H. TEAKLE, Plant Nutrition Officer.

I. A. Superphosphate from Imported and Local Rock Phosphates and Mixtures.

B. Superphosphate made with Half acid—Sub-acid Superphosphate.

II. Superphosphate Mixed with Slaked Lime and Ground Limestone.

III. The Value of Superphosphate and Serpentine Superphosphate for the Growth of Crops in Western Australia.

SUMMARY AND CONCLUSIONS.

DURING 1943 and 1944, a considerable number of experiments with phosphatic fertilisers have been carried out on the Research Stations and private farms, to determine the relative values of various phosphatic fertilisers on the growth of wheat for grain and for pasture, in which subterranean clover was generally dominant. Poor seasonal conditions in some districts interfered somewhat with the experiments and rendered the results less definite than was hoped for; but a number of important conclusions may be drawn.

1. For pastures, superphosphate is at least equal to mixtures of superphosphate with other substances, such as slaked lime, ground limestone, ground serpentine, ground soapstone, or Epsom salts, when the same amount of phosphoric acid per acre is applied in each case.

2. Superphosphate and mixtures of superphosphate with ground limestone, serpentine and soapstone, gave equal results with wheat when used at the same rate of phosphoric acid per acre. Basic superphosphate consisting of superphosphate mixed with slaked lime, proved less effective than superphosphate.

3. Inferior results were obtained when the mixtures were applied at the same rate per acre as superphosphate, and in consequence supplied a smaller quantity of phosphoric acid.

4. The costs of supplying the materials and incorporation in the superphosphate, together with increased handling and transport charges, are not justified by the effect on the growth of pasture or wheat.

5. Ground rock phosphate, supplying phosphoric acid in small amounts equivalent to the superphosphate applications, did not increase the yield of wheat above that obtained with no fertiliser. For pastures, the ground imported rock phosphate had practically no effect; the ground Dandarragan rock phosphate seemed to have a slight effect; and the ground Pelsart Island rock phosphate appeared to be approximately equal to superphosphate. Increasing the fineness of grinding of the Pelsart Island rock phosphate did not increase its effect on the growth of pasture.

6. The mixing of ground rock phosphate with superphosphate did not appreciably increase the availability of the phosphoric acid, as indicated by the growth of pasture or the yield of wheat.

7. Increasing the rate of application of superphosphate generally increased pasture growth, but there were some sites which gave little or no evidence of growth response to superphosphate, apparently owing to the phosphate status of the soil having been built up by previous applications. With wheat, at the site on the Salmon Gums Research Station, there was little or no response to superphosphate.

8. Where response to superphosphate was observed, the optimum application per acre for the promotion of the subterranean clover pasture was of the order of magnitude of 1 cwt. per acre at some sites and up to 2 cwts. per acre at others. At one site the effect of the application of 4 cwts. per acre was outstanding. It is of interest that 56 lbs. of superphosphate per acre gave no evidence of effect on the growth of pasture in a number of instances in the wetter districts. Larger quantities were necessary and the maximum response per unit of superphosphate was obtained with the 1 cwt. per acre dressing. There is apparently a limit to which superphosphate applications can be reduced without reducing the effectiveness of the phosphoric acid for the growth of the crop.

9. In all cases where anaylses were made, increasing the rate of superphosphate increased the phosphorous content of the subterranean clover, and there was a collateral increase in the protein content.

10. The results from the use of sub-acid superphosphate were not as conclusive as desired, but on the average, this fertiliser seemed inferior to superphosphate.

INTRODUCTION.

Shortly after the opening of hostilities, the enemy took measures to interfere with the supply of fertiliser to Australia. Being well aware of the importance of phosphate in our agricultural economy and the part Australia would play in food production for the Empire, action was taken to prevent the mining of phosphate rock at Nauru and shipping was attacked wherever possible. In anticipation of this threat, and in order to meet it, approximately one year's stock of Nauru phosphate had been built up, in addition to that required for current requirements, before the island supplies were cut off.

Other sources of phosphate rock were exploited to maintain, as far as possible, the supply to Australia. For some years the chief source for Western Australia was from Eastern Egypt. The product was low-grade and was mixed with a proportion of rock from Nauru reserves to maintain the quality of the superphosphate.

As the reserves became depleted, larger proportions of the low-grade rock had to be used and the composition of Western Australian superhposphate had to be reduced, until in the latter part of 1944-45 season, the guarantee was only 17 per cent. P_2O_5. Recently, supplies from Egypt have been supplemented by importations from North Africa and the United States of America. The Empire has access to unlimited supplies, at the present time, but it is difficult to obtain adequate shipping for all purposes. However, the superphosphate for Australia in 1944-45 has shown a substantial improvement over the last two years. Western Australia's share in the Australian quota in 1944-45 amounted to 195,755 tons, which is 74 per cent. of the 1939-40 tonnage of 265,000 tons. On account of the lower grade of the present superphosphate, on the phosphoric acid basis, this tonnage amounts to only 60 per cent. of that used in 1939-40.

The superphosphate available to Australia has been rationed between the States on as equitable basis as possible, and has been made available for farmers through the State authorities under a variety of rationing schemes, to ensure maximum production of priority and non-priority crops. Attention has also been directed to measures which may improve the efficiency of the phosphoric acid of our phosphatic fertiliser.

Following European investigations, New Zealand has adopted a mixture of three parts of superphosphate and one part of ground serpentine rock, thinking that this product, containing only 75 per cent. as much phosphoric acid, would be equal to straight superphosphate. Experimentation in Australia failed to support this procedure, and Australian farmers have therefore been supplied with ordinary superphosphate.

This article gives details of the experimental work carried out in Western Australia with various phosphatic fertilisers, including ground rock phosphates, superphosphate manufactured from rock phosphates of local and imported sources, superphosphate manufactured using half of the normal amount of acid, and superphosphate mixed with various substances, including slaked lime, ground limestone, ground soapstone, ground serpentine and Epsom salts.

I. A. Superphosphate from Imported and Local Rock Phosphates and Mixtures.

B. Superphosphate made with Half acid—Sub-acid Superphosphate.

The acute shortage of rock phosphate, brought about by wartime conditions, has lead Australian authorities to seek relief from local deposits. In consequence, research has been organised to discover the facts about known phosphatic deposits in Australia, and experiments have been undertaken to determine whether from them a phosphatic fertiliser, similar in its manurial effect to ordinary superphosphate, can be manufactured. Experiments using superphosphate made by treating phosphatic rock with half of the usual amount of sulphuric acid, have been conducted concurrently. This work has its origin in an endeavour to effect economy in the use of sulphur in the manufacture of superphosphate.

PHOSPHATIC DEPOSITS IN WESTERN AUSTRALIA.

Phosphatic deposits occur in small quantities on certain islands of the Abrolhos group off the west coast, in the Recherche Archipelago, south of Esperance, and in horizons of Cretaceous sediments which occur at Gingin, Dandarragan

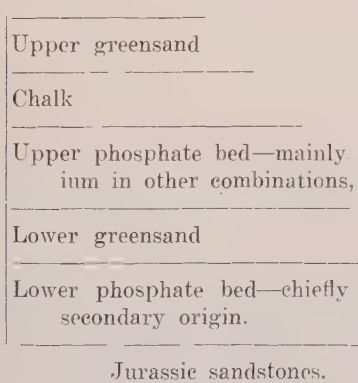
and the Murchison River. The deposits on Pelsart Island, of the Abrolhos Group near Geraldton, are being worked commercially and experiments have been conducted with material from this source. A parcel of phosphatic material from the Dandarragan deposits was obtained for factory and field experiments during 1944.

The Dandarragan Phosphates.

The phosphatic deposits in the Dandarragan district have been investigated by the geologists of the Western Australian Department of Mines, and engineers of the British Phosphate Commission, during recent years. Dandarragan lies about 25 miles west of Moora and 100 miles north of Perth. The phosphate concentrations occur in two bands, each only a few feet thick.

The upper bed occurs at the junction of the chalk and the upper part of the lower greensand. The phosphate is combined chiefly with lime and the material contains a quantity of iron and aluminium in combination with other compounds such as glauconite and felspar. Many of the phosphatic nodules contain about 20 per cent. glauconite as inclusion.

The lower bed of phosphate accumulation occurs at the base of the lower greensand. This is of lower grade, and substantial replacement has occurred with the formation of iron and aluminium phosphates of secondary origin. The accompanying diagram illustrates the mode of occurrence of phosphates in the Cretaceous beds.


Upper greensand
Chalk
Upper phosphate bed—mainly calcium phosphate; some iron and aluminium in other combinations, especially glauconite and felspar.
Lower greensand
Lower phosphate bed—chiefly as iron and aluminium phosphate of secondary origin.
Jurassic sandstones.

Material for the experiments carried out in 1944 was obtained from the deposit on Cook's property, which represents the upper phosphate bed. The sample in question was found to contain 17.5% P_2O_5. Of this, virtually none was soluble in water, and 2% was citrate soluble. This deposit must be regarded as low-grade, and the content of iron and aluminium gives prospect of serious technical difficulties in the manufacture of superphosphate.

The composition of the Dandarragan phosphate is illustrated by the results of a complete analysis of a composite sample of material from five different pits in Cook's deposit. This material had been dressed by removing all that passed from a 1/16 inch screen. The analysis was made in the Government Chemical Laboratory and reported by the Government Geologist.

	Per cent.
SiO_2	46·02
Al_2O_3	2·36
Fe_2O_3	3·38
MnO	0·02
MgO	0·42
CaO	23·62
K_2O	0·80
P_2O_5	16·66
CO_2	1·70
H_2O+	1·29
$H_2O—$	0·98
SO_3—Soluble in water	0·04
SO_3—Acid Soluble	0·15
Cl	0·01
F	Present
Loss of Ignition	0·41
	98·09

Recent petrological work by Dr. K. R. Miles on some phosphate nodules from Cook's deposit shows that all the iron oxide, alumina, potash and magnesia shown in the chemical analysis of the composite sample can be accounted for by the glauconite, iron ore and felspar occurring as inclusions in the phosphate nodules themselves.

The average approximate mineral composition of the phosphate nodules as determined by micrometric analysis is as follows:—

	Per Cent.
Quartz	32½
Collophanite	46
Glauconite	12½
Iron Ore	5½
Felspar	3½
	100

The approximate composition of the minerals associated with the collophanite ($3\ Ca_3(PO_4)_2 \cdot n\ Ca(CO_3, F_2, O)\ (H_2O)x$) has been assumed to be as follows—

Glauconite—SiO_2 52%, Fe_2O_3 20%, Al_2O_3 10%, MgO 3%, and K_2O 3%.

Iron Ore—Fe_2O_3 85%.

Felspar—SiO_2 65%, Al_2O_3 18%, K_2O 16%.

The importance of the iron and aluminium content from the agricultural viewpoint will depend on the reaction between the compounds containing them and the sulphuric acid, and the effect of the products of this reaction on the availability of the phosphates. These reactions will also be of importance in the manufacturing process.

From the agricultural viewpoint, it is generally considered that a high content of iron and aluminium will interfere with the availability of the phosphoric acid after acid treatment, by effecting reversion to a water insoluble condition. While chemical analysis may support this claim in some instances, evidence from field experiments is not regarded as conclusive.

Material required for the experiments was prepared by the fertiliser manufacturers, one company taking responsibility for the preparations involving the use of Dandarragan phosphates, and the other for the remainder. Analyses of the products were made shortly after manufacture, and during June and December of the same year, in order to determine the changes in the composition of the various mixtures on storage. There was little change prior to June. Details of the changes between June and December are given in Table I.

The major changes on storage from June to December occurred in the control sample of commercial superphosphate and in the sub-acid superphosphate. The commercial line was taken from stock. The superphosphate had been mixed with about 4 per cent. ground limestone to reduce the free acid content and afford protection to the jute containers. The added limestone reduced the amount of water soluble phosphate by 10 per cent., and a collateral increase is shown in the citrate soluble fraction. No substantial changes in the content of water soluble phosphate occurred after storage in any of the other mixtures, whether manufactured from Dandarragan rock or mixtures.

In the sub-acid superphosphate, made by using half the normal amount of acid, the bulk of the citrate soluble fraction present in June was converted into the acid soluble fraction by December. A similar reaction occurred in the residue from the sub-acid superphosphate, after washing out the water soluble fraction with water.

It is of interest that during the six months' storage, the superphosphate made from Dandarragan rock increased in the citrate soluble fraction, chiefly at the expense of the acid soluble fraction.

Also of interest is the high citrate soluble fraction of the Dandarragan superphosphate. A similar condition occurs where imported rock is mixed with 20 per cent. glauconite prior to acid treatment. It seems that the products of the reaction between the acid and the glauconite result in the formation of citrate soluble phosphoric acid at the expense of the water soluble fraction. The addition of glauconite to the imported rock is associated with an increase in the acid soluble phosphate, but the low content of free acid suggests that the glauconite had absorbed some sulphuric acid and left insufficient for complete solution of the rock phosphate.

From this work, there is no chemical evidence that the high content of iron and aluminium in the Dandarragan phosphate has seriously reduced the availability of the phosphoric acid converted to the water or citrate-soluble condition by acid treatment.

TABLE 1.

CHANGES IN THE COMPOSITION OF VARIOUS SUPERPHOSPHATES ON STORAGE FOR SIX MONTHS, 1944.

Superphosphate.	Water Soluble P_2O_5.		Citrate Soluble P_2O_5.		Acid Soluble P_2O_5.		Total P_2O_5.	Free Acid H_2SO_4. %	Water Soluble Chloride, expressed as NaCl
	June.	Dec.	June.	Dec.	June.	Dec.			
1. Commercial superphosphate from Imported Rock	16·40	6·70	1·84	12·17	2·05	1·42	20·29	0·25	·06
3. From Dandarragan Rock	3·93	3·39	4·64	7·03	2·88	1·03	11·45	0·88	Trace
4. From Imported Rock II., 90% ; Dandarragan Rock, 10%	14·73	14·62	1·12	1·95	1·93	1·21	17·78	1·18	·15
5. From Imported Rock II., 50% ; Dandarragan Rock, 50%	9·80	9·81	2·97	3·78	2·77	1·96	15·54	1·23	·07
7. From Imported Rock II., plus 20% glauconite	7·01	6·25	7·07	8·21	4·52	4·14	18·60	·39	·23
2. Superphosphate from Imported Rock I. mixed with equivalent amount Imported Rock phosphate	8·27	7·54	3·16	4·07	10·55	10·37	21·98	*Nil*	·38
6. Superphosphate from Imported Rock II. mixed with equivalent amount Dandarragan rock phosphate	6·85	6·73	1·02	2·50	10·46	9·10	18·33	*Nil*	·10
8. Sub-acid superphosphate from Imported Rock I., using 50% acid	8·67	8·11	6·34	·33	1·67	8·24	16·68	·10	·27
9. Leached residue of sub-acid superphosphate	·48	·29	3·88	·35	8·06	11·78	12·42	*Nil*	1·05
10. Dandarragan Rock Phosphate	....	....	2·0	....	15·5	....	17·5	....	....
11. Pelsart Is. Rock Phosphate used in Experiment	....	....	....	....	....	....	25·9	....	....
12. Pelsart Is. Composite Sample. dry basis	·02	....	8·3	....	14·1	....	22·4	....	....
13. Imported rock phosphate	....	....	....	....	....	....	27·62	....	....

The Experiments.

In order to complete the agricultural aspects of the investigations of the geologists, engineers and chemists into the utilisation of the local deposits of phosphatic rock, the Department of Agriculture arranged to conduct a series of experiments during 1944, using wheat as the indicator crop, at the Wongan Hills and Salmon Gums Research Stations, and pasture at 19 sites in the wetter parts of the agricultural areas.

For cereals, these research stations were selected as substantial response to superphosphate was expected. In selecting the sites for the work with pasture, an endeavour was made to secure well-established stands, preferably in which subterranean clover was more or less dominant, and where the soils were likely to give a substantial response to superphosphate. Observations from previous experiments were useful in the selection of some of the sites, but in most cases the decision had to be made after an examination of the soils and a consideration of the opinion of the farmers concerning the country. The co-operation of the farmers in the selection was invaluable, and in most cases the sites finally adopted were suitable.

Some consideration was given to the level of phosphoric acid on which comparisons could most appropriately be made. In view of the law of diminishing returns, it was decided to select a low level, on the assumption that the maximum response to each unit of phosphate applied would be from the first half cwt. of superphosphate. From the results of previous experiments, chiefly in the lower rainfall parts of the clover belt, it was decided to adopt 12.3 lbs. of phosphoric acid (P_2O_5) per acre as the basic level. This is equivalent to 56 lbs. of 22 per cent. superphosphate per acre, and would enable the results of these experiments to be related to many others carried out throughout the agricultural areas. This level proved satisfactory on the lower rainfall sites with pastures, but was too low in the wetter districts.

The season proved very unsatisfactory, generally, and the growth of pastures was greatly restricted by the lack of rain at the beginning and the end of the season. It may be pointed out that the opening rains were very late, and the season cut off two or three weeks earlier than usual. Hot days immediately after the finishing rains caused the pasture to dry off abnormally quickly in a number of cases, and made it difficult to secure yield data of the desired degree of accuracy.

In all experiments the randomised block layout was adopted, and five replications used. With wheat, the fertiliser and seed were sown with a drill, and each plot was one drill-width wide. The area harvested was ⅛ acre for each plot at Wongan Hills, and 1/16th acre at Salmon Gums. In the experiments with pastures the plots were 15 links wide and 40 links long. These are suitable in size for cutting with a mower, and allow adequate buffer on the sides and ends. The fertilisers were broadcast by hand.

Unfortunately, at several sites the growth was too short to cut with a mower, and hand methods had to be used. In a number of other cases, a hot dry spell just before the date selected for cutting caused the pastures to dry off, and yield data were not obtainable. In these instances the growth of each plot was assessed by visual examination, and the response compared by means of a grading system. It is thought that this grading system is of sufficient accuracy to warrant reporting the results in association with the actual yields from other properties.

The Treatments.

In order to cover a maximum of ground in these experiments, six questions were asked in arranging the layout:—

1. What is the response to superphosphate on the selected site?
2. What is the comparative value of superphosphate made from Dandaragan and imported rocks, and from mixtures of these rocks?

3. What is the relative values of the phosphoric acid in ground rock phosphates of various sources, in comparison with superphosphate?
4. What is the effect of mixing ground rock phosphate with superphosphate on the availability of phosphoric acid?
5. What is the value of superphosphate made with half the normal quantity of acid, and of the residue after the water soluble fraction has been washed out by water?
6. Does fineness of grinding affect the availability of Pelsart Island rock phosphate?

It has already been reported in this Journal that ground Pelsart rock phosphate is unsatisfactory for wheat, the availability of the phosphate being probably no more than 20 per cent. of that of superphosphate. For leguminous pastures the position is probably different. Legumes generally have a greater capacity for the absorption of water insoluble forms of phosphate than have cereals. In Illinois, De Turk found that rock phosphate is desirable for application to legumes as a direct fertiliser. The phosphoric acid is absorbed by the legume, and later released, on the decomposition of the residues, for use by succeeding cereal crops. Usually heavy applications—up to 1 ton of ground rock phosphate per acre—are ploughed in before planting the leguminous crop, and the effect lasts for several years. Previous experience in Western Australia suggests that for subterranean clover, superphosphate is generally the cheapest and most effective source of phosphate, although in hot weather, under artificial conditions, rock phosphate may be available to the plant.

Interest in sub-acid superphosphate has been maintained by Mr. A. B. Adams, late of the Muresk Agricultural College, for a number of years. Sub-acid superphosphate is made by treating the rock with a fraction, usually half, of the normal amount of sulphuric acid. This effects an economy in the sulphuric acid, and would be an advantage, provided the product were equally as effective as superphosphate as a source of phosphoric acid. This fertiliser has been tried in England and in Scandinavian countries. Mr. Adams' experiments at Muresk suggested that the sub-acid superphosphate, used in equal quantities, was similar in its effect to superphosphate for subterranean clover.

In the experiments reported in this section all treatments were used at the rate of 12·3 lbs. of total phosphoric acid (P_2O_5) per acre, except on the plots included to determine the effect of various rates of superphosphate, and in the mixture of superphosphate and ground Dandarragan rock phosphate.

The treatments used were:—

1. *Effect of Rate of Superphosphate*:

A.—No fertiliser.
B.—12·3 lbs. P_2O_5 = 56 lbs. 22% superphosphate per acre.
C.—24·6 lbs. P_2O_5 = 112 lbs. 22% superphosphate per acre.
D.—49·2 lbs. P_2O_5 = 224 lbs. 22% superphosphate per acre.
E.—98·4 lbs. P_2O_5 = 448 lbs. 22% superphosphate per acre.

2. *The Comparative Value of Superphosphate from Dandarragan Rock Phosphate and Mixtures*:

K.—Superphosphate from Dandarragan rock phosphate.
L.—Superphosphate from 50% Dandarragan rock phosphate, 50% Imported rock phosphate.
M.—Superphosphate from 10% Dandarragan rock phosphate, 90% Imported rock phosphate.
P.—Superphosphate from imported rock phosphate plus 20% glauconite.

3. *The Effect of mixing Superphosphate and Ground Rock Phosphate*:
   G.—Superphosphate equivalent to 6·15 lbs P_2O_5, and imported ground rock phosphate equivalent to 6·15 lbs. P_2O_5 per acre.
   N.—Superphosphate equivalent to 12·3 lbs. P_2O_5, and Dandarragan rock phosphate equivalent to 12·3 lbs. P_2O_5 per acre.

4. *The Effect of Ground Rock Phosphates.*
   H.—Ground imported rock phosphate.
   O.—Ground Dandarragan rock phosphate.
   Q.—Ground Pelsart Island rock phosphate.

5. *Sub-Acid Superphosphate*:
   F.—Sub-acid superphosphate.
   J.—Residue from sub-acid superphosphate after leaching out soluble fraction with water.

6. *Fineness of Grinding of Pelsart Island Phosphate*:
   X.—Fine grinding.
   Y.—Coarse grinding.

Sieving analyses of the two parcels of Pelsart Island phosphate were as follows:—

Sieve 1 M.M. Mesh	Percentage Passing Sample X.	Sample Y.
20	99·2	92·5
30	96·7	87·8
40	91·2	81·0
60	70·2	58·2
100	47·7	35·5

THE RESULTS.

The wheat was harvested at the normal time, and the pasture was cut at the growth stage usually adopted for the making of hay. With respect to pastures, of the 19 sites used, 11 were harvested either with a mower or by hand, 4 were graded by visual examination, and on 4 neither harvesting nor visual assessment was possible, owing to failure for a variety of reasons.

Sites on which no growth response to superphosphate was observed were located on the Wokalup Government Farm, on the Denmark Research Station, and on the property of Mr. W. Hamilton, Jardee. On account of the failure of the pasture to show sufficient growth at hay-making time, owing to a variety of causes, no comparisons of the treatment effects were possible on sites on the properties of Messrs. Abel and Co., Boyup Brook; Mr. R. R. Kahan, Kojonup, and Mr. J. Warren, North Dandalup, and on the Pardelup Farm.

The results of the experiments with wheat are given in Table 2, and with pastures in Tables 3 and 4. The yield data for pastures, in terms of tons of hay per acre, are given for the plots under treatment B—commercial superphosphate containing 12·3 lbs. of phosphoric acid, or 56 lbs. of 22% superphosphate per acre. These were taken as the controls. In order to simplify the comparisons, the yields for all other treatments are expressed as a percentage of the yield of the controls on each site. The actual yields can be obtained by multiplying this percentage figure by the yield of the control plots.

The data were subjected to statistical examination by the Forests Department, in order to measure mathematically the significance of the variation between plots and treatments. Variation due to causes other than the treatments was high, and in consequence substantial differences are necessary for significance. An estimate of the difference which would be significant is given at the bottom of the columns in Tables 2, 3 and 4.

For wheat, at Wongan Hills the difference between the control and certain other treatments are significant. At Salmon Gums, however, these differences are small and cannot be regarded as very conclusive.

Of the 11 sites under pasture harvested, three showed little or no growth response to superphosphate, and in consequence are of no value in the assessment of the difference in the availability of the various types of phosphate. On the other eight sites, substantial response was observed. At the Wooroloo Sanatorium the growth was exceptionally poor. Some of the plots had suffered from the depredations of rabbits, and the yield data are not regarded as very reliable. It seems that certain of the control plots had suffered more severely than others from the influence of outside factors. In order to regularise the results, the control treatment was taken as the average of the yields from the three treatments K, L and M, involving superphosphate made from Dandarragan rock and mixtures of Dandarragan and imported rock, applied at a rate equivalent to 56 lbs. of 22% superphosphate per acre.

TABLE 2.

EFFECT OF PHOSPHATIC FERTILISERS ON THE YIELD OF WHEAT.

Each plot, except under Treatment L., received 12·3 lbs. P_2O_5 per acre = 56 lbs. 22 per cent. superphosphate. Treatment L. received 24·6 lbs. P_2O_5 per acre, half as superphosphate and half as ground Dandarragan rock phosphate.

Fertiliser Treatment.	Yield of Wheat.			
	Wongan Hills.		Salmon Gums.	
	Bus. per acre.	Per cent. Super. from Imported Rock.	Bus. per acre.	Per cent. Super. from Imported Rock.
1. *Relative Yields with Superphosphate from Various Rocks and Mixtures.*				
A. No fertiliser	19·0	78	13·6	91
B. From Imported Rock	24·5	100	14·9	100
G. From Dandarragan Rock ...	19·6	80	15·3	102
H. From Dandarragan Rock, 50%; Imported Rock, 50% ...	23·4	96	16·6	111
J. From Dandarragan Rock, 10%; Imported Rock, 90% ...	23·0	94	15·6	105
L. From Imported Rock 12·3 lbs. per acre plus untreated ground Dandarragan rock phosphate 12·3 lbs. per acre	24·5	100	16·5	111
D. From Imported Rock 6·15 lbs. per acre plus untreated ground Imported Rock phosphate 6·15 lbs. per acre	22·4	91	16·6	112
M. From Imported Rock mixed with 20% Glauconite	22·1	90	15·7	106
2. *Relative Yields from various Ground Rock Phosphates.**				
E. (*a*) Imported Rock	17·9	73	13·2	89
K. (*b*) Dandarragan Rock	19·2	78	14·6	98
3. *Relative Yields from Sub-Acid Superphosphates.*				
C. Sub-acid superphosphate ...	20·4	83	16·0	107
F. Residue from sub-acid superphosphate after leaching out water soluble fraction	18·8	77	14·4	97
Difference necessary for significance P @ ·05	2·9	12	1·9	13

* Experiments with ground Pelsart Island Phosphate Rock in 1943 showed 0·6 bushels of wheat per acre increase over no fertiliser at the Wongan Hills Research Station, as compared with 3 bushels with the same amount of superphosphate. Teakle and Cariss (1944).

Subterranean Clover leaves. August 1944
Phosphorus content % P
Rate of Superphosphate - cwts per acre
Lefroy
Duggan
Chambers
Clune
Stephens
Sanatorium
Fig. 1
Relative hay yields - per centage of control
Fig. 2
Sulfered severe mite attacks
Protein content - per cent
Fig. 3

TABLE 3.

EFFECT OF PHOSPHATIC FERTILISER ON THE YIELD OF PASTURE HAY (10% MOISTURE).

The yields are given in tons per acre for the control plots, receiving 12·3 lbs. P_2O_5 (56 lbs. 22% superphosphate) per acre as commercial superphosphate made from imported rock. The yields from all other treatments are given as a percentage of the yields from the control plots.

Data for Sites Showing Substantial Response to Superphosphate.

	Application of P_2O_5 lbs. per acre.	Lefroy, Lyon's Camp.	Duggan, Yericoin.	Chambers, Walebing.	Clune, New Norcia.	Stephens, Bindoon.	Sanatorium, Wooroloo.	Farleigh, Boyup Brook.	Forrest, Boyup Brook.	Average.
Average Annual Rainfall, ins.	....	16·21	17·71	20·20	21·36	24·74	34·94	27·33	27·33	....
Rainfall, 1944, ins.	....	11·45	17·30	16·03	17·26	*	*	22·00	22·00	....
Yield of Hay with control—56 lbs. 22% Superphosphate—Tons	12·3	·46	·82	·73	·91	1·63	·38†	·46	1·13	.. .
Fertiliser Treatment.										
1. *Effect of Rate of Application of Commercial Superphosphates.*										
A. No fertiliser	*Nil*	75	70	68	69	96	56	57	88	72
B. Superphosphate 56 lbs. per acre	12·3	100	100	100	100	100	‡	100	100	100
C. Superphosphate 112 lbs. per acre	24·6	93	96	101	100	110	103	142	134	110
D. Superphosphate 224 lbs. per acre	49·2	130	116	120	112	118	106	157	143	123
E. Superphosphate 448 lbs. per acre	98·4	119	98	120	127	126	116	295	141	143
2. *Relative Yield with Superphosphate from Dandarragan Rock and Mixtures.*										
K. Dandarragan Rock	12·3	104	90	100	89	97	92	118	100	99
L. Dandarragan Rock, 50% ; Imported Rock, 50%	12·3	116	110	100	81	98	102	92	104	100
M. Dandarragan Rock, 10% ; Imported Rock, 90%	12·3	104	63	96	78	102	106	94	105	94
P. Imported Rock plus 20% Glauconite	12·3	87	71	86	87	96	109	90	102	91
3. *Effect of Mixing Ground Rock Phosphate with Superphosphate.*										
G. Imported Rock Phosphate, Commercial Superphosphate	12·3	106	94	84	79	93	98	70	85	89
N. Dandarragan Rock Phosphate, Commercial Superphosphate	24·6	86	77	97	96	103	90	98	104	94
4. *Relative Value of Phosphoric Acid in Ground Rock Phosphates.*										
H. Imported Rock Phosphate	12·3	79	65	74	63	87	67	·54	83	72
O. Dandarragan Rock Phosphate	12·3	112	78	71	79	96	90	48	104	85
Q. Abrolhos (Pelsart) Island Rock Phosphate	12·3	93	120	92	93	93	84	92	113	98
5. *Sub-Acid Superphosphate– Half Acid.*										
F. Sub-acid Superphosphate	12·3	105	66	78	101	102	101	78	100	91
J. Residue after leaching out water soluble part	12·3	79	86	84	81	88	53	78	90	80
Difference necessary for significance P —										
·05 ±	....	25	34	24	27	19	36	33	22	29

* Information not available. † Average yield from treatments K, L, and M. ‡ Yield discarded on account of discordant results.

TABLE 4.

EFFECT OF PHOSPHATIC FERTILISERS ON THE GROWTH OF PASTURES, JUDGED BY VISUAL EXAMINATION. GROWTH GRADING 0–10.

	Application of P_2O_5 lbs. per acre.	Holmes, Byford.	Collins, Forrest Grove.		Beckett, Metricup.		Button, Carbarup.	Average Grade.
		Nov.	Aug.	Nov.	Aug.	Nov.		
Average Annual Rainfall, inches	....	36·38	46·18		39·21		24·89	....
Rainfall 1944, inches	....	24·72	*		37·03		16·82	....
Fertiliser Treatment.								
1. *Effect of Rate of Application of Commercial Superphosphate.*								
A. No fertiliser	*Nil*	1	0	0	3	2	6	2
B. Superphosphate 56 lbs. per acre	12·3	6	6	2	7	6	8	6
C. Superphosphate 112 lbs. per acre	24·6	8	8	5	7	6	8	7
D. Superphosphate 224 lbs. per acre	49·2	10	8	6	8	9	9	8
E. Superphosphate 448 lbs. per acre	98·4	10	10	10	10	10	10	10
2. *Relative Yield with Superphosphate from Dandarragan Rock and Mixtures.*								
K. Dandarragan Rock	12·3	4	6	2	5	7	7	5
L. Dandarragan Rock, 50% ; Imported Rock, 50%	12·3	No Data	5	2	6	7	6	5
M. Dandarragan Rock, 10% ; Imported Rock, 90%	12·3	No Data	6	2	5	6	8	5
P. Imported Rock plus 20% Glauconite	12·3	4	4	1	6	6	8	5
3. *Effect of Mixing Ground Rock Phosphate with Superphosphate.*								
G. Imported Rock Phosphate, Commercial Superphosphate	12·3	No Data	4	2	6	6	6	5
N. Dandarragan Rock Phosphate, Commercial Superphosphate	24·6	7	6	3	6	6	8	6
4. *Relative Value of Phosphoric Acid in Ground Rock Phosphates.*								
H. Imported Rock Phosphate	12·3	3	2	1	3	5	6	3
O. Dandarragan Rock Phosphate	12·3	4	3	0	4	3	7	4
Q. Abrolhos (Pelsart) Island Rock Phosphate	12·3	4	5	2	3	5	7	4
5. *Sub-Acid Superphosphate—Half Acid.*								
F. Sub-Acid Superphosphate	12·3	4	5	2	6	6	7	5
J. Residue after leaching out water soluble part	12·3	4	3	1	3	6	7	4

* Information not available.

When the results for the eight experiments with pastures reported in Table 3 are considered together, it is probable that differences in the average of about 8 per cent. can be taken as significant. A difference of 5 per cent. may be given some weight in forming a judgment.

With respect to the four sites reported in Table 4, the visual grading was based on the score given each plot in the experiment by two experienced officers. The highest score in each experiment was taken as 10, and the other plots graded accordingly.

The comparisons of the data given in Tables 2, 3 and 4, bring to light a number of points:—

With respect to wheat, the results from Wongan Hills suggest that the commercial superphosphate, made from imported rock, is more effective for wheat than that prepared from Dandarragan rock. As would be expected, ground rock phosphates gave no evidence of any effect in raising the phosphate availability of the soil. As the results from Salmon Gums are inconclusive, and the comparisons do not support some of the important effects indicated at Wongan Hills, it is considered that further experimentation with superphosphate made from Dandarragan rock is necessary to establish its suitability for the growing of wheat.

The comparisons with respect to the pasture experiments made in Tables 3 and 4, show that there is generally an increase in the growth of pasture as the rate of soluble phosphoric acid is increased. In the drier districts the relative response is greater for the smaller amounts of added superphosphate, and little increase is observed with the larger amounts. It is probable that at least 1 cwt. per acre of superphosphate would be the optimum dressing under these conditions. Where the rainfall is higher, the response to small dressings of superphosphate, of the order of magnitude of half cwt. per acre, was disappointingly low, and maximum benefits were obtained from the application of larger amounts. It is probable that about 2 cwt. per acre would be an economical dressing until the land had been built up to a substantial phosphate status.

The most spectacular response to superphosphate was observed on Mr. Farleigh's property at Boyup Brook. Here the plots receiving 4 cwt. of superphosphate per acre stood out like little steep-sided hills of green subterranean clover scattered among the plots where the pasture provided shorter cover under an application which was generally equivalent to 56 lbs. of superphosphate per acre. It was of interest that, at this site, the actual increase in yield for each half cwt. of superphosphate appeared to be similar with dressings up to the top quantity used, 4 cwt. per acre.

With respect to the sources of phosphate, there is no apparent difference in the availability of the phosphoric acid in superphosphate, whether made from imported rock, from Dandarragan rock or from mixtures of imported and Dandarragan rock, as indicated by the growth of the pasture. Furthermore, the ground Pelsart Island rock phosphate appeared to give similar growth increase to superphosphate when applied in equivalent amounts of phosphoric acid.

The ground rock phosphates from imported sources (Egypt) and Dandarragan were of low availability. In fact, the Egyptian rock phosphate gave no indication of growth effect at all, while plots receiving the Dandarragan rock phosphate appeared to have sustained slight benefit.

Mixing ground rock phosphate and superphosphate gave no evidence of advantage, as the effect appeared approximately equivalent to the superphosphate content of the mixture, and bore little or no relation to the content of ground rock phosphate.

With respect to the comparisons of sub-acid superphosphate and commercial superphosphate, the position is not as clear as would be desired. In a number of instances both gave similar growth of pasture, but in others the superphosphate was distinctly superior. On the average, the results favoured commercial superphosphate in comparison with sub-acid superphosphate. A further comparison of sub-acid superphosphate and the commercial line was made independently by Mr. Farleigh, in the suggestion of Mr. Adams. The two fertilisers were put in the drill box, one in one half and the other in the other half. The drill was set to sow one bag of fertiliser per acre and strips were treated across subterranean clover pasture. Throughout the growing period the pasture on the half receiving commercial superphosphate had an obvious advantage over the sub-acid superphosphate, and at hay-making time yield estimates were made by means of a mower, taking four cuts for each treatment. The average yield of hay for each treatment was as follows:—

Commercial superphosphate—0.68 tons per acre.
Sub-acid superphosphate—0.28 tons per acre.

The fact that the mower does not cut very closely to the ground magnifies the differences in growth, so that the actual feed value from the pasture would not be as divergent as indicated by the hay figures. Furthermore, it is possible that the sub-acid superphosphate did not drill as fast as the commercial line on account of a degree of lumpiness. However, the difference in growth was so substantial that it can hardly be attributed to the differences in the rates of drilling.

In Mr. Adams' experiments, which indicated that sub-acid superphosphate was similar in its effect to commercial superphosphate for subterranean clover, Nauru Island rock phosphate was used. It is possible that the divergence in results is due to this fact. Had Pelsart Island rock been used in these experiments, it would probably have been found that the sub-acid and ordinary superphosphates were similar in effect for pasture.

It may be concluded that the evidence available does not point to sub-acid superphosphate, at least when made from Egyptian rock, being equivalent in availability for pasture to the commercial superphosphate, in which the bulk of the phosphoric acid is soluble in water. The treatment using the residue from the sub-acid superphosphate after the soluble material had been washed out, does not give evidence of any improvement in the availability of the rock phosphate not attacked by the acid in the preparation of the sub-acid fertiliser. For wheat, the sub-acid superphosphate at Wongan Hills proved definitely inferior.

The collateral tests with Pelsart Island rock phosphate of different degrees of fineness of grinding were harvested in a number of cases and examined visually in others. The yield data and the visual examination point to no improvement in the growth of pasture where the grinding had been finer.

THE EFFECT OF RATE OF APPLICATION OF SUPERPHOSPHATE ON THE CHEMICAL COMPOSITION OF THE SUBTERRANEAN CLOVER.

Not only does the superphosphate affect the amount of growth, but also the composition, and often the feeding value may be greatly improved by the fertilisers. With respect to six of these experiments, samples of subterranean clover, selecting the leaves and leaf stalks, or petioles, were taken in August, 1944, from the plots receiving the various rates of commercial superphosphate. The sampling was confined to the subterranean clover, and a particular part of the plant, in order that the results would be comparable from one site to another, irrespective of the presence of other grasses and clovers in the pasture. In this month the plants would be just about at the initiation of flowering, a suitable physiological stage in which to make comparisons with respect to composition. The phosphorus and protein contents of the subterranean clover collected in August have been determined and the results are given in Table 5.

Subsequently, at harvest time, samples of the hay were taken for analysis, but the results of this work are not yet available.

Increasing amounts of superphosphate greatly increased the phosphorus and protein contents of the subterranean clover, and the increase continues up to 4 cwts. per acre, the maximum used in all six cases sampled. There is evidence that the effect of increasing the amount of superphosphate falls off with the higher rates, and the limit of increase would be reached at a little higher than 4 cwts. per acre, in most cases.

It is of considerable interest that high protein is associated with the high phosphorus, the increase in relation to the application of superphosphate being parallel. This is particularly important where protein is required to supplement cereal feeds which are of low protein value.

TABLE 5.

THE PHOSPHORUS (P) AND PROTEIN (N × 6·25) CONTENT OF THE LEAVES AND PETIOLES OF SUBTERRANEAN CLOVER SAMPLED IN AUGUST, 1944, IN RELATION TO THE RATE OF APPLICATION OF SUPERPHOSPHATE.

Site.	Composition of the Leaves and Petioles (per cent. dry matter).				
Superphosphate application in terms of lbs. per acre of 22% super.	0.	56.	112.	224.	448.
	PHOSPHORUS (P).				
Lefroy, Lyons Camp	·175	·246	·265	·277	·304
Duggan, Yericoin	·211	·268	·291	·359	·383
Chambers, Walebing	·221	·270	·302	·334	·372
Clune, New Norcia	·203	·225	·230	·262	·320
Stephens, Bindoon	·230	·241	·239	·276	·296
Sanatorium, Wooroloo	·189	·198	·228	·266	·300
	PROTEIN (N × 6·25).				
Lefroy, Lyons Camp	24·7	25·7	26·8	27·4	29·3
Duggan, Yericoin	24·5	27·5	29·0	29·6	30·1
Chambers, Walebing	26·4	27·0	28·6	28·6	30·0
Clune, New Norcia	23·6	24·1	24·2	25·7	23·8
Stephens, Bindoon	24·2	25·0	25·0	24·7	25·9
Sanatorium, Wooroloo	25·3	25·0	26·3	27·1	28·1

The relationship between the phosphorus content of the subterranean clover leaves and three other factors—(a) the rate of superphosphate application; (b) the subsequent yield of hay; (c) the protein content—is illustrated in Figures 1, 2 and 3. The hay yields are given in relative terms and the figures express for each treatment the percentage yield in comparison with the control, receiving 56 lbs. of commercial superphosphate per acre. There is a high positive correlation in each case.

II. SUPERPHOSPHATE MIXED WITH SLAKED LIME AND GROUND LIMESTONE.

The success of high-grade basic slag as a phosphatic fertiliser for pastures, especially under wet conditions in Great Britain, has led to a demand for fertilisers in which the phosphoric acid is insoluble in water but soluble in weak solvents, such as citric acid and ammonium citrate. Some people consider that these fertilisers are advantageous in being less acid than superphosphate and less liable to react with the soil, particularly if the soil is rich in ironstone, and become unavailable to the plant.

High-grade basic slag is the by-product of the old Bessemer process in steel manufacture. This process is not now widely used, and attention has been turned to substitutes. Of these, the so-called basic superphosphate, generally made by

mixing 85 parts of superphosphate with 15 parts of slaked lime, has been most widely used in Australia.

In 1923 experiments were carried out in Western Australia with high-grade basic slag, basic superphosphate and superphosphate for the growth of pastures in the South-West. Results have been reported by Baron Hay (1925, 1926) and Hampshire (1927). In two experiments with basic slag, carried out on W. Water's property, Balingup, and W. Arnott's property, Jarnadup, basic slag did not prove equal to superphosphate, when the application involved the same amount of P_2O_5 per acre. Over two years, the yield of pasture with basic slag was only 75% of that with superphosphate.

With basic superphosphate, two experiments were carried out in the Bridgetown district in the same period, and showed that this fertiliser was at least equal to superphosphate when the same amount of phosphoric acid per acre was involved in each case.

In 1925 a further set of experiments with basic superphosphate and basic slag was carried out, including sites on the Denmark Research Station, Group 42, Denmark, Group 29, Peel Estate, and Group 5, Manjimup. In these cases all fertilisers were applied at the rate of 2 cwts. per acre, and the actual application of phosphoric acid in each case would be to the advantage of the plots treated with superphosphate. As plots receiving no fertiliser were not included in this series, the actual response per unit of phosphoric acid cannot be determined, but the results suggest that the phosphoric acid in basic superphosphate and basic slag was at least equal to that of superphosphate.

The results of these four experiments may be summarised as follows:—

Fertiliser.	Application of P_2O_5 per acre. lbs.	Relative Yield of Hay.
Superphosphate, 22% P_2O_5	49	100
Basic slag, 17% P_2O_5	38	86
Basic superphosphate, 14% P_2O_5	31	84

The suggestion that mixtures of superphosphate and slaked lime were more satisfactory on ironstone soils has been further tested by Neal Smith (1944), in South Australia, on Kangaroo Island and Waitpinga. The results indicate that no advantage is obtained by the mixing of the slaked lime and superphosphate, and that the yields were proportional to the application of P_2O_5, whether in the form of commercial superphosphate or the superphosphate-lime mixtures.

In order to obtain further information regarding the effect of mixing slaked lime and ground limestone with superphosphate, and in view of the interest taken in this subject by Mr. E. Farleigh of Boyup Brook, an experiment was laid down on his property in 1944, using these fertilisers. The effect of the addition of slaked lime and ground limestone to superphosphate is the reduction of the water soluble fraction. The slaked lime is more active in this reaction and leaves only a trace of water soluble fraction after the mixture has been allowed to stand for a few weeks. Analyses of commercial superphosphate, superphosphate plus 50% slaked lime and superphosphate plus 61% ground limestone, which is equivalent in alkalinity to 50% slaked lime, are shown in Table 6. The mixtures were prepared in March, 1944, and analyses made in June and December.

TABLE 6.

ANALYSES OF PHOSPHATIC FERTILISERS, SHOWING PERCENTAGE OF P_2O_5 SOLUBLE IN VARIOUS SOLVENTS AND EFFECT OF STORAGE FOR 6 MONTHS.

Superphosphate.	Analysis of Fertiliser.						
	Water Soluble (P_2O_5).		Citrate Soluble (P_2O_5).		Acid Soluble. (P_2O_5).		Total.
	June, 1944.	Dec., 1944.	June, 1944.	Dec., 1944.	June, 1944.	Dec., 1944.	
	%	%	%	%	%	%	%
Commercial Superphosphate	14·75	9·83	2·67	7·58	1·86	1·87	19·28
Superphosphate plus 50% slaked lime	Trace	Trace	9·68	8·96	3·49	4·21	13·17
Superphosphate plus 61% ground limestone, equivalent in alkalinity to 50% slaked lime	1·24	1·17	8·23	9·12	2·06	1·24	11·53

The effect on the growth of subterranean clover pasture was tested in a 4 x 4 randomised block experiment. The fertiliser was applied by means of a drill, and the rates were adjusted so that each block received an equivalent of 1 cwt. of 22% superphosphate or 24·6 lbs. of phosphoric acid (P_2O_5) per acre. A treatment involving the application of no fertiliser was included in the layout. The plots were cut by means of a mower at the end of October, 1944, and the hay yields determined. The results are given in Table 7.

Statistical analysis of the results shows that the growth differences between the treatments are not significant and it may be concluded that all three fertilisers gave substantially the same effect per unit of phosphoric acid, as far as the growth of hay was concerned. The residual effect will be determined by cutting these plots again in 1945. Samples of the hay have been taken for analysis to determine the effect on the chemical composition. These results are not yet available, and will be reported later.

TABLE 7.

YIELD OF PASTURE HAY FROM PLOTS RECEIVING SUPERPHOSPHATE AND MIXTURES OF SUPERPHOSPHATE WITH SLAKED LIME AND WITH GROUND LIMESTONE.

E. Farleigh, Boyup Brook, 1944.

Fertilisers.	Phosphoric Acid (P_2O_5) Applied.	Yield of Hay.
	lbs. per acre.	tons per acre.
None	...	0·28
Commercial superphosphate	24·6	0·90
Superphosphate plus 50% slaked lime ...	24·6	0·83
Superphosphate plus 61% ground limestone, equivalent in alkalinity to 50% slaked lime	24·6	0·86
Difference for significance P = ·05	...	0·18

The results of this experiment give no indication of advantage accruing from the mixing of slaked lime or ground limestone with superphosphate for the growth of subterranean clover pasture on soils containing ironstone in the Boyup Brook district. The yield of pasture is not reduced by the incorporation of slaked lime in superphosphate, as is the case with wheat for grain. There is no evidence so far to indicate that the extra costs involved in mixing the lime or ground limestone and the superphosphate are warranted.

III.—THE VALUE OF SUPERPHOSPHATE AND SERPENTINE SUPERPHOSPHATE FOR THE GROWTH OF CROPS IN WESTERN AUSTRALIA.

For many years it has been recognised that silicates promote phosphate absorption by plants. The earliest work recorded is that carried out at the Rothamstead Experimental Station, where in 1864 experiments were laid down including silicate of soda as a fertiliser. Over a considerable period this material was found to give a substantial increase in growth of barley on plots deficient in phosphate and which received no phosphatic fertiliser. The increase amounted to several bushels per acre.

The mode of action of the silicate was long in dispute, but it now appears that the addition of silicate to the soil effects a release of soil phosphate owing to a phenomenon now described as anion exchange. Further, there is important evidence that the silicate in the plant increases the efficiency of the phosphate itself. Apparently the silicate has little direct effect on the growth of the crop. With respect to the soil, the silicate has been found to promote depletion owing to the more rapid release of the phosphate. Of course, this may readily be compensated for by the use of phosphatic fertilisers.

The effect of silicate on the availability of soil phosphate has evoked interest in many parts of the world, particularly in Germany and Japan, where it was hoped that the use of locally produced silicates would help to replace imported phosphates which may be difficult or impossible to obtain. Unfortunately, or perhaps fortunately for the allies, these hopes have not materialised.

Parallel with the interest in silicates either as fertilisers or included in fertiliser preparations, there has been an increasing amount of attention given to fertilisers in which the phosphoric acid is not water soluble as in superphosphate, but is soluble in somewhat stronger solvents, such as ammonium citrate, 2 per cent. citric acid or acetic acid. The interest in these fertilisers arises out of the success of basic slag or Thomas' phosphate, which was a by-product of the old Bessemer process for the manufacture of iron. With a modification of the furnace technique, the slag is of very much reduced value as a fertiliser and artificial means of preparing a substitute have been examined.

In Europe, particularly in Germany, a considerable number of artificial fertilisers, generally prepared by furnace treatment to render the phosphate soluble in ammonium citrate or citric acid, have been put on the market. Experiments to determine the value of these fertilisers in comparison with the standard superphosphate have in many instances indicated at least equal availability of phosphoric acid. The success of these fertilisers in Germany, and also in other parts of the world, led to a trial in Western Australia in 1932. The manufacturers of Rhenania phosphate kindly made available a parcel of one ton of their fertiliser to the Department of Agriculture and it was tried as a fertiliser for wheat and pastures in comparison with superphosphate. In general, superphosphate proved superior and the prospects of the use of such fertilisers were not further examined.

Publications from Germany (Hock (1931) Niklas et al (1932)) indicate the direction of attention to fertilisers prepared by mixing superphosphate with certain types of rocks ground to a very fine state of division. The usual rock was one known as dunite, which is relatively soluble in weak acids and generally contains a fair proportion of a common mineral known as olivine. Olivine is a form of magnesium silicate occurring in basic rocks and readily changes into another form known as serpentine. Serpentine is a greenish-grey mineral, so named from the resemblance of the mineral in colour to the skin of a serpent. Both olivine and serpentine are usually associated with other elements, including iron, cobalt, phosphorus, etc. Serpentine closely resembles asbestos and soapstone in many respects. Soapstone in pure form is known as talc and is the basis for the manufacture of toilet powders.

The results were sufficiently attractive to interest the Russians, whose workers published reports in 1936 (Druzhinin, 1936). The Russians used the dunite primarily to correct the acidity and improve the physical properties of triple superphosphate.

The favourable reports from Europe interested New Zealand workers, and experiments were undertaken by the agricultural chemists in 1938, using first dunite and later serpentine for admixture with the superphosphate. In New Zealand, three parts of hot fluid superphosphate as it came from the mixers, and one part of ground dunite, or later, serpentine, were incorporated and allowed to mature.

The mixture was examined to determine the chemical reactions involved and its value as a fertiliser in comparison with superphosphate. It was found that the addition of the ground serpentine reverted the bulk of the water soluble phosphoric acid, changing it to forms insoluble in water but soluble in the stronger solvents, such as 2 per cent. citric acid, ammonium citrate or acetic acid. Askew (1942) suggests that the possible constituents of the serpentine-superphosphate mixture are as shown in Table 8.

TABLE 8.

THE COMPOUNDS OF SERPENTINE SUPERPHOSPHATE.

Askew (1942).

Name.	Formula.	Per Cent.	Soluble in.
Mono-calcium phosphate	$Ca(H_2PO_4)_2.2H_2O$ ...	1·9	Water Urea
Dicalcium phosphate	$CaHPO_4.2H_2O$ ...	3·6	Citric acid Acetic acid
Tri-calcium phosphate	$Ca_3(PO_4)_2$ ...	17·7	Hydrochloric acid
Calcium sulphate	$CaSO_4$	36·7	Hydrochloric acid
Di-magnesium phosphate	$MgHPO_4.7H_2O$ ...	29·1	Citric Acid Acetic acid
Un-reacted Serpentine	...	7·0	...
Iron and aluminium oxides	...	0·5	...
Silica	SiO_2 ...	4·7	...
Hygroscopic moisture	...	1·9	...

The hydration of di-magnesium phosphate ensures a dry fertiliser which maintains good physical properties and the basic properties of the serpentine neutralises free acids of superphosphate.

A comparison of the analysis of typical superphosphate, basic superphosphate (made with slaked lime) and serpentine superphosphate is shown in Table 9.

Table 9.

ANALYSIS OF SUPERPHOSPHATE, BASIC SUPERPHOSPHATE, AND SERPENTINE SUPERPHOSPHATE.

Fertiliser.	Phosphoric Acid (P_2O_5).			Lime (CaO).			Magnesia (MgO).		
	Water.	2% Citric acid.	Hydrochloric acid.	Water.	2% Citric acid.	Hydrochloric acid.	Water.	2% Citric acid.	Hydrochloric acid.
	%	%	%	%	%	%	%	%	%
Superphosphate...	18·78	0·51	1·00	14·06	2·63	11·59	·13	*Nil*	·23
Basic superphosphate	2·22	18·68	?	4·69	18·25	11·74	?	?	·30
Serpentine superphosphate ...	2·90	11·27	4·73	1·70	12·75	12·35	2·20	2·65	1·85
Ground Serpentine	...	2·06	·11	...	4·59	·54	...	·51	31·62

In this table, the citric acid soluble fraction does not include that soluble in water and similarly, that soluble in hydrochloric acid excludes the other two fractions.

The value of the serpentine superphosphate, as it is now called, as a fertiliser in New Zealand, has been studied in an extensive series of field experiments. These have been reported by Elliott (1940), and Elliott and Lynch (1941). In all, 237 comparisons were made between superphosphate and serpentine superphosphate using equal weights of each fertiliser. As the serpentine superphosphate mixture consists of three parts of superphosphate and one part of serpentine, an equal weight of the serpentine superphosphate mixture will contain only three-quarters of the amount of phosphoric acid (P_2O_5). Of the comparisons made, 160 were purely observational, in which 3 cwts. of superphosphate were compared with 3 cwts. of serpentine superphosphate. Apparently no control strips with no fertiliser were used to determine whether or not any response to phosphate at all would be obtained.

Using such liberal amounts of phosphate per acre, it is possible that in either case, adequate phosphate was applied even for highly deficient soils. Further, visual observations are not reliable unless very substantial differences in responses occur. Where the yields obtained are of the same general order and there are no comparisons with unfertilised plots, such methods cannot be regarded as very conclusive.

In these and in some of the more carefully conducted experiments there were a number of sites on which the equal weight of serpentine superphosphate gave equal or better results than superphosphate. The favourable response appears to be related to soil types and it is likely that these are sites where the soils are deficient in magnesium and the magnesium content of the serpentine superphosphate was responsible for the advantage. Furthermore, on soils deficient in cobalt and associated with "bush sickness," the small cobalt content may be effective in improving the feeding value of the pasture. On soils, too, where the fixing power for water soluble phosphate is considerable, this form of phosphatic fertiliser would be expected to be most satisfactory.

EXPERIMENTS IN AUSTRALIA.

As a result of the enthusiasm of certain New Zealand agriculturists for the serpentine superphosphate mixture and the assumed economy in phosphoric acid and sulphur, the British Phosphate Commission introduced a parcel into Australia. Through the agency of the Council for Scientific and Industrial Research, this fertiliser was made available for experimental work in several of the States to ascertain the value under local conditions.

Published reports so far do not favour the serpentine superphosphate. For instance, in experiments in which subterranean clover was grown in pots using as the soil the Cressy shaley clay loam from Tasmania, it was found that 5 cwts. of serpentine superphosphate gave only 92 per cent. of the yield of 3 cwts. of superphosphate per acre. Stephens et al (1942).

In Western Australia, in 1943 a comprehensive series of experiments with pastures and wheat was organised to compare serpentine superphosphate with superphosphate, and also mixtures of superphosphate and three other substances. These mixtures were—ground limestone one part to superphosphate three parts; locally produced soapstone one part to superphosphate three parts; and Epsom salts—so that the magnesium content would be equivalent to that of the serpentine superphosphate.

The results of the experiments with cereals have been reported by Teakle and Cariss (1944) and are summarised in Table 10.

TABLE 10.

YIELDS OF WHEAT GROWN WITH SUPERPHOSPHATE, SERPENTINE SUPERPHOSPHATE, AND SUPERPHOSPHATE PLUS SOAPSTONE.

——	No Super.	68 lbs. 18% Super.	62 lbs. Serp. Super.	83 lbs. Serp. Super.	Super. and Soapstone.
22% superphosphate	...	56	42	56	42
Lbs. P_2O_5 per acre	...	12·3	9·2	12·3	9·2
Salmon Gums—					
Yield—bushels per acre ...	12·2	14·6	13·4	14·6	14·6
Per cent. of 56 lbs. super. per acre	84	100	92	100	100
Wongan Hills—					
Yield—bushels per acre ...	4·8	7·2	6·8	7·0	6·8
Per cent. of 56 lbs. super. per acre	67	100	94	97	94

Under these conditions there is no doubt that serpentine superphosphate, weight for weight, is inferior to superphosphate for cereals, but is equal when compared on an equivalent phosphoric acid basis.

The experiments with pasture were more comprehensive, and included the following treatments, the amounts being expressed, for simplicity, in terms of P_2O_5 per acre. It may be noted that 1 cwt. of 22% superphosphate contains 24·6 lbs. of P_2O_5.

A.—No fertiliser.

B.—Superphosphate 18.4 lbs. of P_2O_5 per acre.

C.—Superphosphate 24.6 lbs. of P_2O_5 per acre.

D.—Superphosphate 49.2 lbs. of P_2O_5 per acre.

E.—Serpentine superphosphate 18.4 lbs. of P_2O_5 per acre.

F.—Serpentine superphosphate 24.6 lbs. of P_2O_5 per acre.

G.—Superphosphate 3 parts, ground limestone 1 part, 18.4 lbs. P_2O_5 per acre.

H.—Superphosphate and Epsom salts, 18.4 lbs. P_2O_5 per acre, and magnesium equivalent to the serpentine superphosphate.

J.—Superphosphate 3 parts, soapstone 1 part, 18.4 lbs. P_2O_5 per acre.

The experiments were laid out on selected areas of pasture where subterranean clover was apparently dominant, and where a substantial response to phosphate was expected. The nine treatments were arranged in a randomised block layout, using five replications, giving 45 plots. Each plot was 40 links long and 15 links wide, a size convenient for cutting with a mower in order to determine yield. The paddocks were stocked and free grazing allowed until August. After this time, the stock were removed and the paddocks shut up for hay-making when the pasture was ready.

The season proved poor for pasture growth on most of the sites, but good yields were obtained on several properties. The exceptionally dry spring conditions were responsible for an early maturation of the pasture, and the reduction of the spring growth which was expected to provide a measure of the response to treatment. In many cases the growth was restricted and the yields were small and difficult to measure accurately.

Of the 14 sites on which the experiments were laid out, 13 were cut for hay and one had to be abandoned, as the pasture had died off before the cut could be obtained. Seven gave a good response to superphosphate, and of these, five made fair to good growth. On two, the growth was very severely affected by drought. The results from the remaining six were unsatisfactory for the comparisons, either on account of irregular growth and drought conditions or little or no growth response to superphosphate. In view of this, the results are segregated in the table into four groups—

A. Normal growth, and substantial growth response to superphosphate.

B. Substantial growth response to superphosphate, but quantity severely affected by drought.

C. Drought conditions caused irregular growth, and data are regarded as unreliable.

D. There was little or no growth response to superphosphate.

The treatments were repeated on the same plots in 1944, on Mr. J. Duggan's property, Yericoin. Drought conditions obscured the comparisons between the different rates of superphosphate and the growth with ¾ cwt. superphosphate equalled that with 2 cwt.

The results from the 1943 experiments are expressed in detail in Table 11.

For ease of comparison, as in the 1944 experiments, the yields in terms of tons of hay per acre are given only for the control treatment—1 cwt. of 22 per cent. superphosphate per acre, which is equivalent to 24.6 lbs. phosphoric acid (P_2O_5) per acre. These yields are taken as 100 per cent. for each site, and the yields of all other treatments are expressed as a percentage of this control.

The results indicate that on the seven sites included in groups A and B. where more or less reliable results have been obtained, the growth of the pasture is closely correlated with the amount of phosphoric acid applied in the fertiliser. The addition of serpentine, ground limestone, ground soapstone and Epsom salts had no measurable effect on the growth of hay, and apparently did not improve the efficiency of the phosphoric acid applied.

TABLE 11.

THE RELATIVE EFFECTS OF PHOSPHATIC FERTILISERS AS SUPERPHOSPHATE, AND OTHER MIXTURES, ON THE YIELD OF HAY, TAKING 24·6 LBS. OF P_2O_5 PER ACRE, AS SUPERPHOSPHATE, AS 100 PER CENT.

Site.	Rainfall.		Actual Yield of Hay with Super., supplying 24·6 lbs. P_2O_5 per acre. (tons per acre)	Superphosphate.			Serpentine Superphosphate.		Superphosphate plus Limestone.	Superphosphate plus Epsom Salts.	Superphosphate plus Soapstone.	Difference for Significance P = ·05 ± %.
	Average. (inches)	1943. (inches)										
P_2O_5 Applied—lbs. per acre				...	18·4	24·6	49·2	18·4	24·6	18·4	18·4	18·4	...
Equivalent amount of 22 per cent. super.—cwts. per acre				...	¾	1	2	¾	1	¾	¾	¾	...
A.—Normal Growth and Substantial Growth Response to Superphosphate.													
Clune, New Norcia ...	21·36	20·63	·53	58	74	100	91	84	109	96	82	92	37
Stephens, Bindoon ...	24·74	28·27	1·10	45	70	100	100	85	96	85	77	97	26
Chapman Research Station, Nabawa	18·26	14·92	·86	72	124	100	126	110	95	95	102	117	30
Wright, Kirup	...	32·14	1·97	84	102	100	117	83	99	98	87	104	31
Button, Carbarup	24·89	24·44	·70	26	75	100	135	73	99	70	74	65	48
Average "A" ...	...	...	...	57	89	100	114	87	100	89	84	95	...
B.—Substantial Growth Response to Superphosphate, but yields severely affected by drought.													
Duggan, Yericoin {1943	17·71	20·63	·29	41	85	100	129	78	79	76	90	76	21
Duggan, Yericoin {1944	17·71	17·30	·90	43	102	100	123	102	92	91	120	96	...
Chambers, Walebing ...	20·20	20·37	·33	36	114	100	109	103	121	97	121	111	72
Average "B" ...	...	...	...	40	100	100	120	94	94	88	110	94	...
C.—Drought Conditions Caused Irregular Growth and Yield Data considered Unreliable.													
Angel, Jardee	...	36·93	·50	57	60	100	85	75	72	77	91	86	...
Hunter, Pemberton ...	53·64	46·02	·68	107	117	100	...	121	137	...	...	...	...
Research Station, Denmark	46·85	43·97	·40	153	160	100	229	135	143	120	156	129	...
D.—Little or No Growth Response to Superphosphate.													
Page, Boyanup	39·69	34·28	3·14	105	99	100	88	84	96	103	112	98	...
School of Agriculture, Narrogin	20·15	23·36	1·02	96	87	100	94	87	121	91	72	83	...
Hitchins, Cranbrook ...	20·12	19·59	1·82	88	110	100	89	76	81	119	107	80	...

Chemical Composition of the Subterranean Clover.

In order to obtain information regarding the effect of the treatments on the composition of the pasture, subterranean clover was selected as the indicator plant, and leaves and leaf stalks or petioles were sampled from plots under several of the treatments. It was thought that this information would give a measure of the status of subterranean clover in Western Australia with respect to various elements and point to possible deficiencies, as well as the need for superphosphate on each site, apart from the growth response.

There has been a little evidence of magnesium deficiency in New Zealand and certain parts of Australia. However, in Western Australia, although the continuous use of superphosphate on light soils might be expected, similarly, to lead to depletion of magnesium and the development of associated deficiency disorders, none of the past field experimental work gives evidence of response to magnesium fertilisers. Growers of vegetables, particularly cabbages, in some of the metropolitan areas, use Epsom salts in their fertiliser mixture, as they consider that better growth and quality is the result. There is no experimental evidence to support this.

Analyses of subterranean clover leaves and petioles on the superphosphate, serpentine superphosphate and superphosphate plus Epsom salt plots from seven sites, have been made, and the data with respect to magnesium and calcium are reported in Table 12.

Table 12.

THE CALCIUM AND MAGNESIUM CONTENT OF SUBTERRANEAN CLOVER LEAVES AND PETIOLES, SAMPLED AT HAY-MAKING TIME, FROM VARIOUS FERTILISER TREATMENTS.

	Date Sampled.	Constituent.	Super.	Serp. Super.	Super. and Epsom Salts.
Stephens, Bindoon ...	11–10–43	Magnesium	·62	·56	·58
		Calcium	2·49	2·36	2·64
Chambers, Walebing ...	13–10–43	Magnesium	·63	·71	·56
		Calcium	3·35	3·67	3·32
Duggan, Yericoin ...	15–10–43	Magnesium	·46	·62	·52
		Calcium	3·37	3·96	3·86
Page, Boyanup ...	4–11–43	Magnesium	·30	·30	·29
		Calcium	1·44	1·61	1·79
Wright, Kirup ...	2–11–43	Magnesium	·48	·40	·51
		Calcium	1·76	1·50	1·83
Hitchins, Cranbrook ...	3–11–43	Magnesium	·33	·34	·33
		Calcium	1·29	1·17	1·31
Button, Carbarup ...	4–11–43	Magnesium	·34	·37	·33
		Calcium	1·83	1·85	1·80

This information gives no evidence of improvement in the magnesium content of subterranean clover as a result of using fertilisers containing this element. The magnesium content of the subterranean clover from the sites at Boyanup, Cranbrook and Carbarup appears to be on the low side, but the use of fertilisers

containing magnesium were without effect. An increase would be expected from the use of Epsom salts in the fertiliser mixture were the subterranean clover to be growing under sub-optimal magnesium conditions in these instances.

Of interest is the substantially higher magnesium and calcium figures from Bindoon, Walebing and Yericoin samples, which are from dry districts where the Dwalganup strain of subterranean clover has established. The reason for this is obscure and involves a fundamental problem in plant physiology. It may also be of importance in the nutrition of animals.

Further analyses on the samples from the superphosphate plots for protein, phosphorus and potassium were also made, and are reported in Table 13.

TABLE 13.

THE PROTEIN, PHOSPHORUS AND POTASSIUM CONTENT OF SUBTERRANEAN CLOVER LEAVES AND PETIOLES, SAMPLED AT HAY-MAKING IN 1943 AND AGAIN IN AUGUST, 1944, FROM THE YERICOIN PLOTS.

Site.	Date Sampled.	Super. Application (22% P_2O_5).	Protein.	Phosphorus P.	Potassium K.
		cwt. per acre.	%	%	%
Stephens, Bindoon ...	11–10–43	¾	21·6	·14	3·52
Chambers, Walebing ...	13–10–43	¾	18·5	·12	3·68
Duggan, Yericoin ...	15–10–43	¾	19·4	·13	3·57
Page, Boyanup ...	4–11–43	¾	17·5	·17	1·39
Wright, Kirup ...	2–11–43	¾	20·2	·18	1·53
Hitchins, Cranbrook ...	3–11–43	1	17·7	·13	2·01
Button, Carbarup ...	4–11–43	1	14·2	·12	2·22
Duggan, Yericoin ...	Aug. 1944	...	26·6	·20	...
		¾	30·6	·28	...
		1	30·8	·32	...
		2	31·8	·36	...

The figures indicate a sound potassium status, but the phosphorus is low and the protein only moderately high for the samples taken at haymaking. Of interest in comparison, are the figures for the samples taken in August, 1944. At this growth stage the phosphorus and protein contents are high and there is a substantial response in phosphorus and protein content as the application of superphosphate is increased. The importance of growth stage on the composition of the plant is emphasised.

CONCLUSIONS.

Study of the data from these experiments gives rise to the following conclusions:—

(1) Serpentine superphosphate, weight for weight, is inferior to superphosphate with respect to the yield of wheat for grain and the growth of pasture in Western Australia.

(2) When the fertilisers are used on an equivalent phosphoric acid basis, the serpentine superphosphate, superphosphate, and mixtures of superphosphate with ground limestone, with ground soapstone and with Epsom salts all gave yields of wheat and pasture which were substantially the same. The incorporation of the serpentine or other substances has not reduced the availability of the phosphoric acid in fertiliser, nor has it improved its efficiency.

(3) There appears to be no justification for the incorporation of serpentine or similar material in superphosphate under average Western Australian conditions for the growth of wheat or pastures as there is no apparent economy in the use of phosphate. The availability of the phosphoric acid is not improved, and the preparation and increased bulk of the mixture would involve much extra manpower, material and transport.

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Quality in Eggs.

E. LOVEGROVE and S. FROOME.

TO maintain the original quality as long as possible in so perishable a product requires great precaution in caring for eggs on the farm and through all the steps necessary to bring them to the consumer. Normally the hen lays a good egg, and research has shown that more than 99 per cent. of all eggs are clean before they come in contact with the nesting material. *Keeping eggs clean and maintaining internal good quality are primarily the responsibilities of the farmer.*

The influence of micro-organisms on the keeping quality of eggs has been the subject of considerable investigation because much of the deterioration in fresh eggs results from the growth of bacteria. The contents of normal new-laid eggs, as a rule, contain no bacteria. Normally the shell prevents contamination, and egg white is germicidal to a number of types of micro-organisms, including pathogenic types, but under conditions of high moisture and the presence of dirt and filth, bacteria enter eggs through the shell. The finding of large numbers of bacteria in eggs is an indication of improper handling and often of insanitary conditions.

The main types of rot found in new-laid eggs are classified as "green whites," "red rots" and "black rots," and with these present, deterioration proceeds so rapidly that within a few days the eggs are no longer edible. If eggs received at packing floors are already bacterially affected, it is impossible to stop the process of deterioration, although the eggs may appear sound and pass the candling test.

In 1938 the Council for Scientific and Industrial Research commenced a programme of investigation and research work to determine the causes of deterioration in egg quality, particularly in regard to wastage in eggs after being held in cold storage for any appreciable length of time. In 1943 a report was released by the Egg Producers' Council covering the five years' research work by the C.S. and I.R., and the following general conclusions were made:—

1. Cleaning machines, normally found on farms, are the important source of the rot-producing bacteria. During the machine cleaning, the bacteria penetrates into or through the shells to situations where they are protected from external influences. All the evidence of experiments is in agreement that the machines are reservoirs of infection.

2. Experiments have proved that it is difficult, even with the greatest care, to maintain a washing machine in a state of bacterial cleanliness. The machine which appears to be scrupulously clean may be seriously infected with bacteria.

3. The use of certain disinfectants in suitable concentrations has resulted in the reduction of wastage, but their proper application would not be capable of satisfactory supervision and half measures would not be effective. Also, certain useful disinfectants would be injurious to the fabric of the machines, which would require frequent renewal.

4. It is clearly demonstrated that considerable damage may be done by passing eggs which are already clean over cleaning machines, but wastage is very low when eggs are not cleaned, whether they are soiled or not.

5. Several methods of hand cleaning eggs cause only slight wastage provided strict cleanliness is observed, but they must not be washed until several hours after gathering.

The conclusions just described clearly demonstrate that the cleaning of eggs by washing machines assists the growth of harmful bacteria, and has an adverse effect on the keeping quality of the eggs.

In 1941 the Department of Agriculture of Western Australia published a leaflet on the cleaning of soiled eggs, stressing the necessity of preserving the keeping quality and so preventing wastage until they are consumed. The method of cleaning recommended was to dip the eggs for five minutes in a one-half per cent. caustic soda solution, then rinse in clean water. After drying, the eggs were to be packed, and the packed cases fumigated with formalin.

Again in 1941, Messrs. Scanlan & Simper, Ltd., of Fremantle, having in mind the caustic treatment and fumigation recommended by the Department of Agriculture, commenced a series of practical experiments using only those eggs which came from farms affected with "rot." The Poultry Adviser of the Department of Agriculture has been in close touch throughout the period of the investigations, and the following is an extract from a report received by him from Messrs. Scanlan & Simper, Ltd., on March 16th, 1945, after four years of experimental work:—

(1) "Rot" first appears during the month of September. The opinion is that climatic rise in temperature is responsible.

(2) Nest or unwashed eggs are seldom affected with "rot."

(3) Eggs washed under ordinary conditions (other than running water) show up to 80 per cent. to be affected with "rot."

(4) The use of a solution consisting of 1½ ounces of caustic soda to 4 gallons of water resulted in practically no eggs being affected with "rot."

(5) Rot is not conveyed by contact, and fumigation is considered unnecessary.

(6) A most important factor in this treatment is that dirty eggs must be allowed to cool off for several hours before washing.

(7) A close check has been kept on several farms using washing machines with running water only, and the eggs washed by this method were seldom affected with "rot."

(8) Where a washing machine is employed caustic soda solution of the above strength should be used, changing at least once a day.

(9) Having arrived at the above conclusions we had pamphlets printed and distributed amongst our clients.

The results obtained, with their co-operation, were more than satisfactory and reduced the incidence of "rot" to a minimum.

The report also states: "During the present season (1944-45) 'rot' did not appear on our floor until February. Within 14 days four of our clients consigned eggs affected with 'rot.' At the present time our floor is practically free from 'rot' and we respectfully recommend for your consideration the general use of caustic washing until a better remedy is introduced."

The conclusions just described clearly indicate that the cleaning of eggs by washing in a caustic soda solution has an adverse effect on the growth of harmful bacteria and reduces the incidence of "rot" to a minimum.

It is now possible to make definite recommendations to control the deterioration of eggs, caused by bacteria, generally classified as "rot." The hand-cleaning method, using caustic soda solution, is less liable to deteriorate their keeping quality than the use of washing machines, and should be used by producers to the maximum possible extent.

The following procedure is strongly recommended:—

1. Every endeavour should be made to gather the greatest possible percentage of eggs naturally clean. The provision and maintenance of clean nesting material are essential. Highly recommended materials are white shavings, white sawdust and excelsior (wood wool), but if these are not available, straw may be used provided it is clean, dry and free from moulds. Plenty of clean litter should always cover the floor of the poultry shed.

2. Collect the eggs as often as possible. Frequent gathering of the eggs reduces the number of dirty eggs sometimes as much as 50 per cent. Prompt removal of eggs from the nest to a cool room facilitates lowering the temperature. If eggs are not removed and other hens occupy the nests, these eggs may be kept near body temperature for several hours. The cooling of all eggs is important to maintain the quality of thick, firm white and strong upstanding yolk.

3. Separate the clean from the dirty eggs and do not wash the clean eggs. Experiments have shown that wastage is very low when the eggs have not been washed, so do not subject the clean eggs to the risk of infection through cleaning.

4. Allow dirty eggs to cool off for several hours before washing. It has been demonstrated that if eggs are cleaned in water which is colder than the eggs themselves, favourable conditions are set up for bacteria to penetrate the shells, and rotting is induced. As eggs are warm when laid they must be allowed some hours to cool down to atmospheric temperature.

5. When dirty eggs have cooled down dip them in one-half per cent caustic soda solution (½lb. to 10 gallons of water) for five minutes, followed by rinsing in clean water, and then place them, small end down, on wire trays to drain and dry, or wipe with a clean cloth. Then pack and market as frequently as possible.

With regard to the strength of the caustic soda solution, it must be noted that success has been obtained by using a solution of 1½ ozs. of caustic to four gallons of water (approximately one-quarter per cent.), while recent tests carried out by the United States Department of Agriculture, Washington, indicate that a one per cent. solution was satisfactory. The one-half per cent. solution recommended by this Department has proved satisfactory on every occasion on which it was employed.

Possibly in the near future eggs will have to be sent to such places, and in such form, as the British Ministry of Food and the Allied Purchasing Council determine. To supply the orders of the British Government the maximum number of clean, unwashed eggs should be provided for the packing floors. With insufficient clean eggs available the problem of cleaning the dirty eggs in such a manner as not to adversely affect their keeping qualities *is immediate* and important.

The method of cleaning described above should ensure that the product carries satisfactorily to the overseas markets and holds its quality until it reaches the consumer.

Entomological Problems of the Ord River Irrigation Area.*

C. F. H. Jenkins, Government Entomologist.

THE following remarks are based upon observations and collections made during the overland trip to the Ord River, extending from April 17th to July 15th, 1944, and upon various material published and otherwise which I have been able to examine in connection with the area in question. Information is still far too inadequate to allow of a comprehensive report being prepared, since collecting at all seasons of the year has not been possible, and experiments with cultivated plants have not been extensive enough in the area to give a true indication of the number of potential pests which may be present. Sufficient knowledge has been collected, however, to indicate that a number of very serious pests occur in the area and that any agricultural development of the region must be carried out with due regard to the influence of these pests upon stock, horticulture, pastures, and the settlers themselves.

PASTURE PESTS.

Grasshoppers.

Although grasshoppers were not present in plague form during my visit a large variety of specimens was collected. Three species at least are known to swarm in the Kimberleys, namely, the Yellow winged locust (*Gastrimargus musicus*); the Migratory locust (*Locusta migratoria*); and the Spur throated locust (*Austracris guttulosa*). The Yellow winged species caused considerable damage to the Carlton Reach plots, stripping practically all green vegetation in March and April, 1944. These plagues are not necessarily annual, as apparently no damage was done in 1941 or 1942.

The Yellow winged locust is widespread in Western Australia, but only swarms in the northern portion of the State. The Spur throated and the Migratory locusts are also present in the south as well as the north, but migratory swarms are confined to the northern half of the State. The breeding habits of the species described resemble those of the Little plague grasshopper in that the eggs are laid in the ground, but little is known of the particular biology of the creatures in the area under discussion.

Under open range conditions, grasshopper plagues would presumably be of little importance. In the case of cultivated crops however, the position would be very different, and judging from the experience of station managers with vegetable gardens, it may be expected that irrigated areas would suffer heavily just as the natural feed was drying off in March or April.

The following species were collected during my visit:—*Gastrimargus musicus* (the Yellow winged locust); and *Austracris guttulosa* (the Spur throated locust).

CONTROL.

Poison baiting would appear to be the most promising means of control. Investigations to reveal the breeding areas and the main plague centres are also necessary, so that the possibility of any action before the swarms occur may be considered.

* This article is a copy of a report submitted by Mr. Jenkins to the Under Secretary for Agriculture on 11th November, 1944. As such, it should be regarded as a provisional guide to the principal insect problems likely to occur in the region, and not as a comprehensive entomological record.—Editor.

Leafhoppers. (Jassidae.)

Mr. K. Durack regards the leafhopper as the most serious pest on the Carlton plots. It caused severe damage to lucerne in October and November, but no specimens were collected during my visit. It is not yet possible to say how serious the pest really is until the actual species has been identified and its activity during further seasons noticed.

Members of the Jassid family are of considerable importance on many types of cultivated plants throughout Australia. Several are troublesome in the Queensland cotton areas and it is possible that the Ord River species may be identical with one of these northern forms.

CONTROL.

Most leafhoppers present a very difficult control problem. Insecticides are frequently ineffective and the nature of the crops attacked often renders such treatment impracticable. Cultural practices and the development of resistant varieties have in some instances proved profitable lines of investigation.

VEGETABLE PESTS.

It was generally stated by residents that little in the way of vegetables could be grown in the "wet" and most homestead gardens are laid down in about April. Even at this season it is often necessary to protect seedlings against grasshoppers and at the time of my visit, young plants were being raised in sheds and under verandahs where the insects seldom venture. The reasons for the inability to grow plants during the summer were given as "heat and grubs."

Leaf-eating Beetles.

Three foliage-eating beetles were among the most serious vegetable pests collected, with the exception of grasshoppers. The species concerned were the Twenty-eight spotted ladybird (*Epilachna twenty-eight punctata*), the Pumpkin

The Gorge—Ord River No. 1 Dam Site.

beetle (*Aulacophora hilaris*), and an unidentified Chrysomelid. All three showed a great liking for cucurbits, but were found also on lucerne and a wide variety of plants. They are apparently native species as they have a wide distribution in the Kimberleys and feed readily on wild cucurbits as well as other vegetation.

The Leaf-eating ladybird and the Pumpkin beetle are not found in South-western Australia, but on the eastern side of the continent they extend from Queensland to as far south as Victoria.

LIFE HISTORY.

The grub stage of the ladybird is a dull yellow creature covered with numerous dark branching hairs. Both larval and adult stages are foliage feeders. The Pumpkin beetle larvae are also yellowish in colour, but feed at the bases of the stems and on the roots of their host plants.

CONTROL.

Arsenical dusts and sprays are effective against these beetles, but in the case of very young cucurbits some foliage injury sometimes follows treatment. In such cases Derris compounds are recommended.

The Beet Web Worm. (*Hymenia recurvalis.*)

This insect, which causes severe damage to silver beet and red beet in the South-West, is widely distributed in the Kimberleys, and was reported as troublesome at many homesteads. This is probably an introduced pest of tropical or sub-tropical origin. It now has a wide range, including North America, Hawaii, Japan and Australia. It was collected in several homestead gardens, on the plots at Carlton Reach, and also in natural surroundings where the larvae were feeding upon wild *amaranthus.*

CONTROL.

Arsenate of lead is not effective against this pest, but satisfactory control may be obtained with the use of Derris or Pyrethrum.

Grasshoppers.—(See under Pasture Pests).

Termites.—(See under Termites).

MISCELLANEOUS PESTS.

Aphides.—Recorded attacking sorghum at Carlton Reach.

Mealy Bug.—Attacking rosselas at Carlton Reach.

Thrips.—Attacking grass and sorghum.

FRUIT TREE PESTS.

The only fruits growing at Carlton Reach were bananas and pawpaws, and no insect damage to these was noted.

Orange-piercing Moth. (*Othreis materna.*)

On many stations visited citrus, mainly lemons, were grown and it was stated that the Orange-piercing moth appeared in spasmodic plagues and damaged almost all the fruit ripe at the time. This moth was observed on the Carlton plots and was collected at several localities on the trip.

Orange-piercing moths have a wide distribution in tropical and sub-tropical climates, and are of considerable importance in South African orange groves.

LIFE HISTORY.

Little is known of the life history under local conditions, as only the moths have been collected in this State. In other States, however, the caterpillars are reported to feed upon a native climber (*Menispermaceae*). Representatives of this group colloquially known as "Poison Ivy" are widespread in the Kimberleys and, according to the Government Botanist, extend southward to the Fortescue. It seems evident, however, that there are some other local food plants as moth infestations are sometimes severe as far south as Northampton, and although the insects may be carried great distances by wind, this could hardly account for all the more southern outbreaks.

Termite Nest—Gogo Station.

CONTROL.

On account of the life history described above, the difficulty of combating the moth will be apparent. The destruction of all food plants in the vicinity is advised, but is often impracticable. Baits consisting of poisoned syrup destroy large numbers of moths, but often not before considerable damage has been caused. Much work on baiting for the adults has been done in South Africa, and the following mixture has been found most effective:—

½oz. arsenate of soda.
1⅓ pints of treacle.
2 gallons of water.

The best receptacles for holding the bait are petrol tins. They may be cut on the two sides and these lifted to form a verandah to prevent rapid evaporation or flooding with rain. The bottom pan should be about four inches deep. Smaller tins may be hung in the trees and in both cases wood or sponges should be placed in the liquid to support the moths when feeding

Another attractive bait may be made by crushing fruit in a tub or large tin and pouring over it a quantity of the poison solution. When the bait evaporates a little, it is preferable to add water to bring it up to the original level rather than to renew it too frequently, as fermenting bait is more attractive than fresh. Dead moths and other foreign matter, however, should be removed daily.

In South Africa considerable work has been done on picking dates with a view to avoiding the main invasion of moths, and it was found that early picking appreciably reduced the losses.

Fruit Fly.

Lures for both the Queensland fruit fly (*Chaetodacus ferrugineus*) and the Mediterranean fruit fly (*Ceratitis capitata*) were exposed in native fig trees along the Ord River, but no specimens were captured. The most northern record I have of the Mediterranean fruit fly in this State is Carnarvon. The Queensland species has so far not been recorded breeding in this State.

Newman's Fruit Fly (Neodacus newmani).

Specimens of what I believe to be this species were collected around native fig trees. A careful search failed to reveal any fruits infested with maggots and no information as to the host plants is available. It is a native species described in 1937 from specimens "bred from native fruit, Carnarvon, W.A., 1918, Newman." The species showed no attraction to the fruit fly lures of vanilla and ammonia and Clensel used for the better known flies, but was attracted by the aroma of clove oil. There is nothing known concerning the breeding habits of this fly, and consequently no comments can be made upon its possible economic importance.

COTTON PESTS.

No cotton was growing in the area at the time of my visit but the following details are based upon previous investigation made in the State, and upon specimens collected by me in the area.

G. Evans of the Empire Cotton Corporation found the Pink cotton boll worm (*Platydera gossypiella*) attacking experimental cotton at Broome in 1923, and the next year it was found on the Roper River in the Northern Territory. Mr. E. Ballard, Commonwealth Cotton Entomologist, also recorded the pest from Port Hedland, Roebourne, and Carnarvon.

A report from Professor Dunstan, Imperial Institute, London, received in 1922, recorded the presence of the Pink cotton boll worm, and concluded by stating that "in attempting cotton cultivation in Western Australia, it would be necessary to devote great care to the prevention of damage by insects."

L. J. Newman visited the Broome-Derby region in 1923 and recorded the following cotton pests:—

Pink cotton boll worm—*Platydera gossypiella.*
Boll worm—*Heliothis armigera.*
Rough boll worm—*Earias huegeli.*
Cotton stainer bug—*Dysdercus sidae.*
Cotton seed bug—*Oxycarenus luctuosus.*

He also reported that numerous native malvaceous plants widespread in the area supported these pests when cultivated cotton was not available. Extensive areas of native malvaceae were met with from Pardoo to the Ord, and consequently it may be anticipated that all the above pests are widespread in the Kimberleys.

The following were collected by me during the trip:—

Cotton boll worm—*Heliothis obsoleta.*

Rough boll worm—*Earias huegeli.*

From the foregoing it is evident that any cotton growing project in the Ord River region must be undertaken with due regard to the possibility of severe insect attack. It should be noted, however, that identical or very similar pests are present in Queensland and other cotton growing countries, and consequently their presence does not necessarily preclude the possibility of cotton growing in the region.

TERMITES.

Numerous species of termites are to be found in the Kimberley area and extensive damage to buildings and cultivated trees and plants is common.

Three species were identified on the trip, viz.:—

Mastotermes darwiniensis (Broome, Wyndham).

Hamitermes rubriceps (Nicholson st.).

Eutermes triodiae (Mounds widespread from Broome northwards).

A fourth unidentified species was collected attacking peanuts at Carlton Reach.

Mastotermes darwiniensis.

This large termite, measuring half an inch in length, is a very destructive species. Extensive damage caused by it was seen in jarrah woodwork in the Broome hospital.

Mr. Gerald Hill (C.S.I.R.) writing of this species, states, "The discovery of these communities usually is a matter of chance as there rarely is any external evidence of their presence; but one has the impression that under entirely natural conditions *Mastotermes* colonies usually are neither large nor of frequent occurrence. The reverse certainly is the case in settled localities.

"*Mastotermes* is by far the most destructive Australian termite and probably has caused more economic loss than any other insect in the northen part of the continent. Not only has it acquired a taste for many substances essential to man's welfare and progress, but it has acquired almost unbelievable resourcefulness in overcoming his efforts to protect his property. The completeness and rapidity with which *Mastotermes* can, and usually does, carry out its work of destruction is a source of wonderment to those familiar only with the activities of the incomparably less destructive southern termites.

"Amongst the substances known to be destroyed by this termite are all kinds of timber structures, fences, poles, lead sheathing of electric cables, bitumen, paper, bone, ivory, horn, leather, hides, ebonite, asbestos, jute, cotton and other vegetable fibre, silk, woollen fabrics, stored grass hay, sugar, bagged pickling salt and flour. Accumulations of human excreta and the dung of herbivorous animals also are invaded by these termites. In addition to the trees previously mentioned, citrus, soursap, pineapple, vines, cassava, banana, pawpaw, melon, pumpkin, carrot, potato, tomato, and many kinds of shade and ornamental plants are very subject to destruction by *Mastotermes.* In some low-rainfall localities it is practically impossible to produce domestic supplies of the ordinary kitchen garden crops owing to the ravages of this pest, whilst in the Burdekin district of Queensland it has become a major of sugar cane.

"Certain kinds of plants appear never to be destroyed by *Mastotermes;* they include *Ficus* spp., *Melaleuca* spp., *Alstonia verticallosa, Brachychiton* spp., *Erythrina vespertilio,* and the introduced Brazilian rubber and Indian tamarind. Some of these trees, therefore, are particularly valuable as shade and ornamental trees in *Mastotermes*-infested localities.

"Extensive damage or total destruction by *Mastotermes* of farm buildings, stockyards and fences is commonly to be seen in many parts of north Australia, particularly where durable timbers such as *Callitris intratropica* and *Pithecolobium monoliferum* are not available for building purposes. The practical impossibility of maintaining efficient fences on some runs has led in its turn to serious difficulties for the stockbreeder."

Hamitermes rubriceps.

This is a grass and leaf eating termite, but as it mainly inhabits arid and desolate localities, it is of little economic importance in agriculture.

Eutermes triodiae.

The mounds of this species, sometimes reaching a height of 14 feet, are common throughout the Kimberleys. The insect is a grass eater and consequently is not harmful to fencing and buildings. As in the previous species, the mounds might be of importance in connection with aviation landing grounds.

RESISTANT TIMBERS.

The following timbers although not necessarily immune to termite attack are relatively resistant and are serviceable for various purposes:—

Cypress (*Callitris intratropica*).
Coolibah (*Eucalyptus microtheca*).
Cadjuput (*Melaleuca leucodendron*).
Beef Wood (*Hakea arborescens*).

STOCK PESTS.

Buffalo Fly. (*Lyperosia exigua.*)

Host animals.—Buffaloes and cattle, and to a lesser extent, horses, mules, and donkeys.

The buffalo fly is believed to have reached Australia in about 1825, when the first buffaloes were introduced onto Melville Island. In 1838 the beasts were taken to the mainland, and with them the fly. The invasion of Western Australia probably took place about 1910, and since that date the insect has spread throughout the major portion of the Kimberleys, the southern limit being (Wallal (20° south Lat.). The insect thrives best under warm moist conditions, and for that reason it is most active during and just after the "wet" and in coastal areas. Its spread southwards has been checked by the low rainfall belt south of Wallal, and the quarantine regulations which have created a cattle free buffer for some distance south of this point, and the treating of all cattle shipped from North-West ports.

Much theoretical discussion was waged about the possibility of the buffalo fly establishing itself in the south-western portion of this State, and some authorities contend that the fly could not survive our winter. There is not sufficient evidence to prove this contention, and indeed, such as is available tends to support the reverse idea. Newman on two occasions collected buffalo flies from cattle at Robb's Jetty, and provided them with fresh cow manure for egg laying. On each occasion another generation of flies was successfully raised, and as these experiments were commenced in April and concluded in July, the insects were subjected to the full rigours of winter.

Conditions were not favourable for fly activity at the time of my visit, but the insects were quite numerous on beasts on the Carlton plots, and sores were noticeable where the beasts had been scratching.

Many of the station managers, when consulted about buffalo fly, seemed inclined to under-rate the importance of the pest. This may possibly be due to the fact that it is not a disease carrier and consequently is not responsible for any heavy mortality. The losses sustained due to poor condition and other effects of continual irritation upon the cattle are less obvious than those following an epidemic, but are none the less real. Some men, however, for example, Mr. Eric Durack of Argyle Station expressed the opinion that the buffalo fly was of vital importance.

Should any large aggregations of stock occur on irrigated pasture it is quite possible that the pest would increase in importance in such areas. I have no definite evidence at present available to support this contention, but it is felt that the irrigation conditions and the denser population of stock would be conducive to greater parasite development, and artificial control measures would probably be necessary.

Cattle Tick. (*Boophilus annulatus microplus*—B. australis.)

Host animals.—Cattle, also of much lesser importance, horses.

The first official report of tick in Western Australia was in 1896 and it is believed that the pest was introduced into the East Kimberleys by horses coming from the Northern Territory.

In 1897 J. M. Craig visited the Kimberley and reported that the region was not a congenial home for tick. In 1898, however, E. T. Hancock of Queensland stated that he examined 25,000 cattle between Wyndham and the Ord River Downs Station, and that all were heavily infested with tick.

By 1911 practically the whole of the East Kimberleys was infested and the pest had reached the West Kimberley boundary near the Margaret River.

In 1913, a ten mile buffer area was gazetted between East and West Kimberley, but by 1916, the pest had moved 50 miles further westward.

Baobab, near Derby.

In 1916, it appeared at Derby and is now very widely distributed from Wollal northwards. Its spread south is prevented by the dry belt south of Wollal and the enforced dipping treatment of all cattle proceeding south from infested areas.

The first losses from tick fever were reported in the Kimberleys in 1896 and mortality figures grew annually for a number of years. Now the pest is so widespread that the majority of cattle become infested as calves and so develop immunity.

Isolated areas, however, for reasons not yet apparent, are still free of tick despite efforts to establish the parasite and cattle moving through tick country from such regions frequently die in serious numbers.

All stations in the Ord Valley are, I believe, thoroughly infested with cattle tick, but as in the case of buffalo fly, it is possible that irrigation conditions and the concentration of stock may lead to an increase in the numbers of the pest and necessitate the carrying out of dipping or some other control measures.

Blowflies.

Enquiries on the overland route revealed that severe blowfly strike was experienced in 1942 at Wollal, Nalgie, and Mt. Anderson stations. Although no fly specimens were collected at any of these localities it may be inferred that the fly responsible was the primary Green Bottle (*Lucilia cuprina*), for MacKerras (C.S.I.R. pamphlet 60) referring to the probability of the fly being an introduced pest, writes, "This conclusion is supported by information obtained in Western Australia, where serious strike is more recent, and where the progress of strike outbreaks and the occurrence of *L. cuprina* can be traced steadily up the coast.

Mr. G. C. Rose reported that the 1942 outbreak at Mt. Anderson was the first experienced on that property, and this appears to be the present eastern limit of the fly in the Fitzroy basin, and its possible northern limit in the Kimberleys. Enquiries at both Upper Liveringa and Noonkanbah stations further eastwards along the river revealed that no serious fly trouble had ever been experienced there.

An effort was made to collect the commoner blowflies in the Carlton Reach area by exposing kangaroo carcasses and catching the flies attracted both by the fresh and decomposing lure. Several species were captured but none of the better known sheep species were noted. The apparent absence of *L. cuprina* from the Ord River region is not to be wondered at as it is contended that the principal breeding ground of the fly is the body of the living sheep, and as the Ord stations are primarily cattle runs, sheep blowflies find little harbourage.

Blowflies collected:—

Small green blowfly—*Microcalliphora varipes.*
Secondary green blowfly—*Chrysomyia rufifacies.*
Steel-blue blowfly—*Ch. micropogon.*
Undetermined purple species of *Chrysomyia?*

(All the above are believed to be secondaries.)

HUMAN PESTS.

Mosquitoes.

Malaria.

Mosquitoes were not troublesome throughout my visit but both malarial and dengue carrying species are present in the area, and malaria and dengue fevers are endemic to the Kimberley regions.

Two species of *Anopheles* occur in the Kimberleys, *A. annulipes,* which is the common anopheline of the South-West, and *A. amictus.*

Little detailed information is available concerning the malarial history of Western Australia, but a recent Army publication implies that outbreaks are usually associated with the development of small endemic foci in the native population. The lastest outbreak occurred in 1929-34 and began on the Roper River in the Northern Territory and progressed across country to end in the Ord and Fitzroy Valleys.

Dengue.

Aedes egypti, the vector of dengue and yellow fever, is widespread in Western Australia, and was collected on the trip at Meekatharra, Broome, and Halls Creek. Dengue, however, only persists in tropical regions owing to the temperature requirements of the virus. Dengue was reported to be very common at Broome prior to the mosquito control measures instituted by the Army.

The importance of mosquito borne diseases depends largely upon the zeal with which mosquito control is carried out. The success with which the problem is being coped with by the Army shows that the danger can be reduced to a minimum with reasonable precautions. Particularly is this so in the case of the dengue carrier, as *Aedes egypti* is almost entirely restricted to permanent settlement and consequently domestic waters such as tanks, drains, etc., are the important breeding grounds.

QUARANTINE.

In developing a region such as the Ord River Valley where little or no intensive agriculture has been carried on in the past, it is essential to take every possible precaution to prevent the introduction of pests not already established. This does not apply only to commercial introductions, as odd plants and cuttings for domestic purposes are potentially dangerous.

The speed possible with air transport greatly increases the danger, as people may prefer to secure vegetable seedlings, etc., from Perth rather than to raise their own plants from seed. In some cases, such as with fruit trees, seed propagation may not be practicable, but the introduction of plants should be reduced to a minimum and where necessary, should be permitted only after careful inspection.

The future movement of stock into the area, especially if sheep ever came into favour, should also be considered with due regard to parasite introduction. For instance, as far as I am aware, the primary blowfly, *lucilia cuprina,* is not at present in the region, but one fly struck ram might easily lead to the permanent establishment of the insect throughout the entire area.

The possibility of introducing pests into the south should also be carefully remembered. As examples of the possible danger resulting from the careless transfer of material, may be mentioned the Pumpkin beetle and the Leaf-eating ladybird. Both these quite serious vegetable pests extend as far south as Victoria on the eastern side of the continent, and consequently, although it cannot be definitely asserted that they would thrive in the South-West, the risk is much too great to be taken lightly.

The difficulties of effectively implementing inter and intra State quarantine measures are many, but as far as plant pests at least are concerned, if propagation by seeds is insisted upon where at all possible, and other introductions are made

only after careful inspection and perhaps treatment, much future trouble may be avoided or at least delayed. This aspect may be worthy of some publicity as even at this stage small gardens have been started by Government employees stationed in the area and from such small beginnings future troubles could easily arise.

NEED FOR FUTURE WORK.

The foregoing report reveals that a number of serious insect and allied pests are present in the Kimberleys, but before any conclusions can be arrived at concerning the full significance of the insect population of the region there is an urgent need for future investigations.

Fitzroy Crossing, looking South.

Serious as many of the pests are, there is no reason to believe that many of them cannot be combated. So far no serious pest unique to the area has been recorded, and as such crops as cotton are grown in other parts of the world despite enemies, it may be presumed that it necessary the same can be done at the Ord.

The main essential is that the hazards should be known as fully as possible before any extensive scheme is launched, and I would therefore recommend that:—

1. More intensive collecting should be done in the area, especially during the "wet."

2. Experimental plots of cotton, fruits, and other likely crops should be planted as soon as possible and kept under careful observation for insect attack.

3. The grasshopper outbreaks in the area should be carefully recorded and information obtained concerning the breeding grounds and migration of the pest.

4. Provision should be made for an entomologist to visit the area during the "wet," possibly about March, so that the change in the insect population from summer to winter can be noted.

SUMMARY.

1. Grasshoppers of various species swarm in the Ord River region and are important pests to pasture and vegetable crops.

2. Leafhoppers may appear in plague numbers in October and November, and are very destructive to lucerne.

3. Several vegetable pests, including the Leaf-eating ladybird, the Pumpkin beetle, and the Beet webworm are widespread in the Kimberleys.

4. Termites of several species are widespread and of importance as pests of agricultural crops as well as timber.

5. Fruit pests present include the Orange-piercing moth, which is widespread and a notorious pest of citrus.

6. No fruit flies of known economic importance have been recorded from the area, but one attacking native fruits was collected.

7. Cotton pests recorded in the Kimberleys include the following:—Pink boll worm, Common boll worm, Rough boll worm, Cotton stainer bug, and Cotton seed bug.

8. Stock pests of importance include the Buffalo fly and the Cattle tick both of which are widespread. The Sheep blowfly appears to be restricted to the south-western portion of the Kimberleys only.

9. Malarial and dengue fever mosquitos are native to the region.

10. Strict quarantine measures should be observed to prevent both the introduction of pests into the area and the transportation of pests already there to the southern portions of the State.

11. An entomologist should be stationed in the region for some months to do intensive collecting and to observe the insect attack on experimental crops.

APPENDIX.

General entomological collecting was done throughout the trip and approximately 1,000 specimens were collected representing the following groups and species:—

Odonata (Dragon flies) 12.
Orthoptera (Grasshoppers, Cockroaches, etc.) 70.
F. acridiidae 44.
Gastrimargus musicus.
Locusta migratoria.
Austracris guttulosa.
10 unidentified spp.

F. Tettigoniidae 4.
3 unidentified spp.

F. Mantidae 3.
3 unidentified sp.

F. Gryllotalpidae 3.
1 unidentified sp.

F. Blattidae 7.
5 unidentified spp.

Ord. Isoptera (Termites) 20.

F. Mastatermitidae.
Mastotermes darwiniensis 10.
Eutermes triodiae 10.

Ord. Thysanoptera (Thrips) 20

Ord. Hemiptera (Bugs) 25.

F. Reduviidae (Assassin bugs).
1 unidentified sp.

F. Lygaeidae.
1 unidentified sp.

F. Pentatomidae (Shield bugs).
6 unidentified sp.

F. Belostomatidae (Fish killers).
1 *Lethocerus indicus.*

F. Eurybrachidae.
1 unidentified sp.

F. Aphididae.

Ord. Coleoptera 150.

F. Carabidae.
3 unidentified sp.

F. Cerambycidae.
3 unidentified sp.

F. Curculionidae.
6 unidentified sp.

F. Tenebrionidae.
3 unidentified spp.

F. Coccinellidae.
Epilachna twenty-eight punctata (Leaf-eating ladybird).

F. Chrysomelidae.
Aulocophora hilaris (Pumpkin beetle).
2 unidentified sp.

F. Scarabeidae.
5 unidentified spp.

F. Buprestidae (Jewel beetles).
3 unidentified sp.

F. Bostrychidae (Timber borers).
1 unidentified sp.

E. Dytiscidae (Water beetles).
1 unidentified sp.

Ord. Hymenoptera (Wasps and Ants) 300.

F. Bembecidae.
Blastophagidae (Fig wasp in native fig).
Chrysididae.
Sphecidae.
Vespidae.
Braconidae.
Cumenidae.
Chalcidae.
Formicidae (Ants).
Mutillidae.

Ord. Neuroptera (Lacewings).
F. Mantispidae.
F. Mrymelcontidae (Ant lion flies).

Ord. Diptera (Flies) 166.
F. Muscidae.
Lyperosia exigua (Buffalo fly).
Musca vetustissima (Bush fly).
Microcalliphora varipes.
Chrysomyia rufifacies.
C. micropogon.

F. Tachinidae.
Sarcophaga sp.

F. Trypetidae.
Neodacus newmani.

F. Ortalidae.

F. Syrphidae (Hover flies).

Ord. Lepidoptera (Butterflies and Moths) 80.
Butterflies.
22 unidentified sp.
Moths.

Noctuidae (Cutworms).
Heliothis armigera (Climbing cutworm).
Othreis materna (Orange-piercing moth).
6 unidentified sp.
Phycitidae.
Hymenia recurvalis (Beet web worm).

In addition to the entomological collection, specimens of all kinds were collected for the Perth Museum and several new records for the State and some completely undescribed forms were procured.

BIRDS.

Fourteen birds representing 10 species were shot and skinned for inclusion in the Museum reference collection.

Lemon-breasted fly catcher (*Microeca flavigaster*) (1).
Not previously recorded from Western Australia.
Little friar bird (*Philemon citreogularis*) (2).
Black-faced cuckoo shrike (*Coracina novae-hollandiae*) (2).
Little cuckoo shrike (*C. robusta*) (1).

Yellow weebill (*Smicornis flavescens*) (1).
Red-browed pardalote (*P. rubricatus*) (1).
Painted finch (*Emblema picta*) (3).
Grey headed honey-eater (*Meliphaga keartlandi*) (1).
Black-headed pardalote (*Pardalotus melanocephalus*) (1).
Blue and white wren (*Malurus cyanotus*) (1).

FROGS.

Hyla caerulea (2).
H. latopalmata (2).
Cyclorana australis (1).

REPTILES.

Python sp. (immature).
N.W. Frilled lizard (*Chlamydosaurus kingii*) (2).

FISH.

Toxotes jaculator (Rifle fish).
Mullet (probably new species).
Perch (probably new species).

CRUSTACEANS.

Palaemon australis (Long clawed prawn).

Migrating Bees.

L. BLAIR, Government Apiculturist.

IN order to increase honey yield, it has been a practice for very many years to travel hives annually to different districts in order to take advantage of varying blooming periods, and early records show that the ancient Egyptians adopted this method by moving their hives up and down the Nile on barges.

Although various methods are practised to achieve this end, the fundamental requirements for successful travelling are ample ventilation and reasonable coolness. It is obvious that confinement is necessary, and this tends to alarm the bees. In their confusion they consume large quantities of honey and, unless the heat thus generated can be dissipated by efficient ventilation, suffocation will follow and the end of the journey will disclose a sticky mass of dead bees, honey, wax and bee bread.

The usual methods of achieving desirable conditions for travelling can be summarised as follows:—

1. The fitting of a travelling screen of fly-wire or perforated zinc over the hive after removal of the top.
2. Giving the bees a good smoking, then loading after sundown when all bees have returned, and travelling during the cooler hours of the night.
3. The use of spacers between stacked hives.
4. The use of double-decker hives when bees are particularly strong.

Explanatory notes on these are set out hereunder:—

Travelling Screens.—There are many different designs of screens, all more or less on the same principle of substituting a perforated frame for the usual hive top. The author has evolved a most satisfactory screen of a different type which combines with the screen a clamping device and which is now being manufactured locally in three models. There is an eight frame and a ten frame model, and an adjustable one which will fit either. The adjustment is simply and quickly made with one nut and bolt at each end. These screens are designed to provide ventilation in the centre of the hive, being placed between the hive body and the super, and they require considerably less construction material than top screens.

Four corner pieces of heavy gauge iron project about 1in. above and below the screen and these hold the hive and super firmly and prevent any lateral movement. The corners are drilled to accommodate a 1in. nail, thus eliminating any lift when travelling rough roads or when handling.

Smoking and Travelling.—Many bee-keepers adopt the method of smoking, loading and transporting without screens, but whilst simple, this method is suitable only over short distances, and where transportation can be effected over-night. A weakness in this method is the possibility of mechanical break-down to the vehicle and the consequent delay, which may last into the following day, adversely affecting the hives.

Some apiarists follow the method of extracting most of the stores and travelling without a screen after blocking the entrance. The obvious drawback to this is that the bees will receive a serious set-back and a curtailment of brood-rearing will inevitably follow if there are no honey stores on which the bees can draw in the event of the district honey flow being temporarily retarded by unusual seasonal conditions.

An important point which is frequently overlooked is the necessity for keeping the hives as dark as possible whilst being moved. Light excites the inmates and in endeavouring to find a way out of the hive they will cluster on the screen and reduce the ventilation.

Spacers.—It is obvious that any advantage gained by fitting screens, especially top screens, will be neutralised if hives are stacked one upon another without spacers of some sort to allow of free ventilation. In this regard, it should be noted that the screen previously described carries a small block which serves the dual purpose of a spacer and a means of attaching a length of wire with which the lid is kept firm.

Double-decker Hives.—Occasionally strong stocks of bees are travelled in hives which are too small, and trouble, which may not be apparent immediately, frequently follows. The bees will cluster on the screen, thus cutting off a large proportion of the ventilation, and the consequent rise of temperature in the hive may result in scalding the sealed brood and a subsequent reduction of their vitality. I would strongly advise bee-keepers to travel strong stocks, if possible, in double-decker hives.

One point of general interest worth noting is that during the journey the bees would avail themselves of any moisture and generally that would be the liquid food surrounding the small unsealed larvae. This would tend to give the colony a set back when placed on a new flow.

Warning.—It is advisable before starting a journey to make sure the bottom boards of all hives are firmly secured to the body of the hive, as it is most disconcerting, when loading or unloading hives, for a bottom board to become discon-

nected and a shower of hostile bees to be released. When unloading, it is advisable to place all hives in their new positions and allow the bees to settle down quietly before removing travelling screens and entrance screens. Make sure all screens are removed before leaving the new site.

Experiments with Micro-Elements for the Growth of Crops in Western Australia.

X.—MANGANESE FOR POTATOES.

BENEFIT ON SWAMP LAND AT NARRIKUP.

L. J. H. Teakle.

SOME years ago, Mr. H. A. H. Iffla of Yellanup, East Narrikup, reported disappointing growth of potatoes on portions of valuable swamp land which had been damaged by severe burning many years ago. There are reports of a severe fire on this swamp about 50 years ago, and it is thought that the damage occurred on this occasion. After the burning, the rushes and other swamp plants re-established and a peat layer developed over the ashes, but the level of the surface was left somewhat uneven.

The first crop of potatoes on this land, planted about 10 years ago by Mr. Iffla, was very satisfactory and yielded about 13 tons per acre. The second planting on the same land gave only half the yield and many of the plants were very unthrifty. The third crop was virtually a failure. It was noticed that the poorest growth occurred in the slight depressions of the peat surface, where the burnt layer of ash, etc., was shallowest.

After this failure, the unsatisfactory portion of the swamp was depastured with sheep for two or three seasons. This would have a beneficial effect on the soil.

Inspection of the area led to a diagnosis of some nutritional disorder, and, in consequence, a number of experiments have been tried, involving the use of potato manure with and without various mixtures of minor elements.

In 1944, Mr. Iffla carried out an experiment on lines suggested by the writer, using a number of minor elements. The results are given in Table I. and indicate the value of manganese under these circumstances.

Table I.

1944 Experiment.

EFFECT OF MINOR ELEMENTS ON THE YIELD OF POTATOES ON SWAMP LAND.

The minor elements were added to the potato manure.

Minor Element.	Application. lbs per acre.	Yield per two-chain row.	Tons per acre.
Epsom Salts	528	58	3½
Borax	33	60	3½
Bluestone	66	80	4¾
Zinc Sulphate	33	80	4¾
Manganese Sulphate	132	135	8

The experimental work was continued in 1945 by Mr. Iffla, with mixtures provided by the Department of Agriculture. Delaware seed was planted on 9th January, 1945, in well-worked ground, but somewhat on the dry side. Throughout the growing period, all of the plants looked healthy, but where the treatment included manganese the appearance was definitely superior, particularly in the early part of the growing period. It was noticed that towards the end of the period, the control treatment, receiving potato manure only, appeared to gain somewhat on the other plots.

The results are given in Table 2.

TABLE II.

1945 Experiment.

EFFECT OF MINOR ELEMENTS ON THE YIELD OF POTATOES ON SWAMP LAND.

Planted 9/1/45—Dug 17/5/45.

Treatment.	Yield per row of two chains. lbs.	Yield per acre. Tons.
A. Control— Potato manure and Bluestone, 12 cwt. per acre	60	3½
B. Control, plus Manganese sulphate, 28 lbs. per acre ..	90	5¼
C. Control, plus Manganese sulphate, 28 lbs. per acre Zinc sulphate, 5 lbs. per acre Borax, 5 lbs. per acre Epsom salts, 1 cwt. per acre	85	5
D. Control, plus Zinc sulphate, 5 lbs. per acre Borax, 5 lbs. per acre Epsom salts, 1 cwt. per acre	65	3¾

Manganese deficiency of potatoes has been recorded from marly swamp country at Little Grove, Albany, on the property of Mr. B. H. Burvill (see *Journal of Agriculture*, March, 1939, page 119). The deficiency is indicated by a bronzing or yellowing of the leaves of the potatoes, accompanied by unthrifty growth and low yield where the manganese deficiency is acute. Where the deficiency is mild, apparently the top growth appears normal, but is reduced in amount, and the yield of the potato tubers is small. The leaf symptoms of acute manganese deficiency in potatoes should not be confused with potash deficiency. In acute potash deficiency, the yellowing and bronzing of the leaves usually extends from the edges, and the leaves become rough and rigid. Later, the edges die and the condition is described as "leaf scorch." With acute manganese deficiency, the yellow and bronze leaves are flat and, to the feel, are thin and smooth.

The results of Mr. Iffla's experiments indicate that farmers observing unsatisfactory growth of potatoes on swamp land under similar conditions should experiment with manganese sulphate in the fertiliser mixture, when growing potatoes. It is recommended that from 28 lb. to 56 lb. of manganese sulphate per acre be used and applied mixed with the potato manure. Other crops, such as peas, tomatoes and beans are also likely to benefit.

ACKNOWLEDGMENT.

Thanks are expressed to Mr. Iffla, who carried out these experiments and has made available the results for publication.

The Use of Jarrah for the Manufacture of Butter Boxes.

(W.A., 1943-44.)

Report assembled by M. Cullity, Superintendent of Dairying and F. Gregson, Utilisation Officer, Forests Department.

INTRODUCTION.

FOLLOWING trials with local timbers for butter boxes carried out at the end of 1942 and early in 1943, and covered by a report by the Superintendent of Dairying in the March, 1943, issue of the *Journal of Agriculture*, orders were placed by the Butter Manufacturers' Association for 100,000 jarrah butter boxes for use on the local market.

Early experimental work emphasised the necessity for using seasoned timber in the manufacture of cases, and showed that unsprayed dry jarrah gave considerably less taint than hemlock or spruce, and sprayed jarrah boxes were very satisfactory from the point of view of taint-transmitting quality even when stored for some time. Experiments were undertaken as it was feared that insufficient hoop pine boxes would be available to carry butter for storage or export. To test the position with regard to approval of jarrah cases for export, 196 cases were forwarded to London for trial and examination by the Commonwealth Dairy Officer.

Following adverse but indefinite complaints on jarrah boxes during 1943, it was felt by the Dairy Products Marketing Board that despite favourable results of early tests the suitability of jarrah boxes was not as widely recognised as desirable and that a further demonstration was required to bring results home to all concerned. With this object in view, Dr. G. L. Sutton late in 1943 contacted interested parties and arranged a further demonstration with the following co-operating:—

Dairy Products Marketing Board.
Department of Agriculture.
Butter Manufacturers' Association.
Safety Box Company.
Forests Department.
Commerce Department.
Timber Control.

At the same time arrangements were made for a number of jarrah boxes already in cool store to be tested for moisture content with examination for taint by officers of the Departments of Agriculture and Agriculture and Commerce. This experiment was carried out at Sunny-West cutting and grading plant and at the Western Ice Works, Perth. The bulk of the butter was packed in October, 1943, and was examined during the period 13th December, 1943, to 12th January, 1944. The results indicated that the moisture content of the boxes was not excessive and that the surfaces of the butter were not seriously affected by wood taint, although the boxes were not sprayed.

The graders commented on the taint varying from slight to very strong, but considered—even in the latter cases—that the taint was not sufficient to affect the sale of the butter. It was found that the strongest taints were associated with contact with boards of high moisture content. (See Appendix 1.)

OUTLINE OF MAIN DEMONSTRATION.

Six hundred jarrah wire-bound boxes, with moisture content tested by an Officer of the Forests Department, and sprayed under his supervision, were manufactured and distributed to a number of butter factories after suitable marking to ensure identification. As a control, an equal number of sprayed hoop pine export boxes were used, half of each type of case.

After packing, each box was branded with a special code mark and forwarded to the Fremantle Cool Store in the usual way, test procedure thus being consistent with normal commercial practice.

Butter was consigned to the Fremantle Cool Store late in December, 1943, and in early January, and grading and general examination of sample cases was carried out on the 4th and 5th April with a few cases held over till the 18th April. This represents approximately three months' storage. The detailed examination was carried out by the Departments of Agriculture and Agriculture and Commerce, but representatives of all parties interested met at the Fremantle Cool Store on 5th April and general results of tests were demonstrated.

SUMMARY OF RESULTS.

The degree of taint found in the butter packed in sprayed jarrah boxes compared favourably with that in butter packed in sprayed hoop pine. It was better than in hoop pine boxes with 3-ply ends of other timber.

It was the opinion of the graders that the wet paper-liners and free moisture were responsible for any taint found in butter from the jarrah boxes.

Some difficulty was experienced because of the paper-liners adhering to the boxes, due apparently to some defect in the evenness of the spraying.

The butter from one factory was machine-packed, three paper-liners being used. No difficulty was experienced with this butter.

The red colour of jarrah allowed any sawdust left in the boxes to become obvious as it adhered to the edges of the butter.

PRACTICAL APPLICATION.

As a general result of tests, to date approximately 50,000 jarrah boxes sprayed and consigned were used in 1943 and to the end of September, 1944, and a further 55,000 boxes had been delivered to factories. These quantities have materially assisted in avoiding a serious shortage of boxes in this State, due to difficulties in securing hoop pine from Queensland. Practical results have borne out those of tests and demonstration with regard to tainting of butter, and show that jarrah is suitable, at least as a standby, for the local market. There are, however, recognised disadvantages in use of jarrah—mainly a tendency of boards to warp after spraying, colour, greater weight—and these points must be taken into account when considering the future of the jarrah butter box.

A very considerable improvement has been made by the substitution in February, 1944, of the hoop pine plywood end for the two pieces of jarrah. This improves the appearance, ease of assembly, rigidity and possibility of re-use. Some improvements in technique can also be anticipated in the way of better selection of timber and improvement in spray practice. With regard to the latter, considerable improvement has already been effected during the current year and the box as a whole is now very much superior to that forwarded to London for trial late in 1943.

APPENDICES.

1. **Survey of moisture content of boxes in Cold Store.**
2. **Manufacture of boxes.**
3. **Detailed examination of boxes.**

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1. Survey of Moisture Content of Boxes in Cold Store.

Extracts from Report to Deputy Conservator of Forests by Assistant Forester F. Gorringe, dated 22nd January, 1944. (Omitting detailed observations.)

Jarrah Butter Boxes.—Moisture content tests carried out since 3rd December, 1943. Two sets of tests were made.

(a) At Western Ice Co. on boxes stacked in cold store. Moisture content ranged from 12 to 18 per cent.

(b) At Sunny West Dairies, butter being cut and packed, butter tasted by Messrs. Cousins and Quigley.

Comments on the butter in this report are from discussions at tests and notes made by Mr. Cousins and are subject to further comment by him.

"At Sunny West a group of boxes were brought out of the thawing room, the butter tasted and the box tested all round with a moisture meter. Varying degrees of taint were obtained in single boxes, i.e., good spots on bad boxes and bad spots on good. These were noted and their position in relation to the box checked with the moisture content of the timber. It was found that where there was a decided higher moisture content at one section of the box the taint was worse at that point.

It was possible to obtain different moisture contents in a single board, differences up to 4 per cent. being obtained. If tests taken at cold store and grading table are compared, it will be seen that the cold store readings are generally lower, indicating that the boxes are picking up moisture from condensation in the thawing room.

Further indications of this were seen in a group of boxes emptied on the afternoon of the 22nd December. To check this, 10 boxes were tested in the cold store and then placed in the thawing room and tested again when they were brought out for cutting and packing. Increases in moisture content from 2 per cent. to as much as 7 per cent. were noted.

During the test it was noticed that in many instances the butter had actually come into contact with the jarrah which was having a direct bearing on the degree of taint. This was due to insufficient paper wrapping, two papers 48in. x 12in. being used one each way over the butter. These became misplaced during packing and the butter became exposed.

I would suggest a third paper be used around and over the other two. Of the 143 boxes tested at Sunny West, only 13 of them were sprayed and the taint was generally less on these.

It is suggested that if a sprayed box of seasoned jarrah be used, and the butter effectively wrapped to avoid contact with the box, the chances of taint would be very small."

2. Manufacture of Boxes.

This was carried out by the Safety Box Factory, Fremantle, with the co-operation of the late Mr. F. Simper, under the direction, with regard to moisture content and spraying, of Mr. Gorringe of the Forests Department. In all, 600

jarrah boxes were manufactured and sprayed on 9th December, 1943. Seventy to eighty boards taken at random were tested for moisture content, using a full range electrical moisture meter, and timber would be described as complying with an 18 per cent. moisture content specification.

Some difficulty was experienced in the spraying of boxes due to the mixture used and insufficient pressure at the spray gun, but a reasonable spray was obtained before proceeding to the spraying of 600 test boxes.

The formula attempted for casein was—

Casein prime, 56 lbs.,
Water, 190 lbs.,
Caustic soda, 4½ lbs.,

and the mixture was heated in order to get a uniform flow. Better results were obtained by breaking down the solution by increasing the water to 270 lbs. This resulted in a formula close to that now recommended by Dr. Wiley, as follows:—

Casein, prime lactic, 1 part by weight.
Water, 5 parts by weight.
Caustic soda, 1/16th part by weight.

A formalin mixture, which was applied after the casein spray, was made by diluting one part of commercial formalin (40%) with seven parts of water.

During manufacture, jarrah boxes were marked for identification purposes. Boxes were distributed as follows:—Bunbury, 300; Spearwood, 200; Albany, Capel, Denmark and Narrogin, 25 boxes each.

Packing and despatch of a proportion of boxes from Bunbury, Spearwood and Capel factories were seen by officers of the Forests Department, acting in the capacity of observers only.

3. Detailed Examination of Boxes.

The following detailed comments on the examination of the butter were prepared by the graders (Mr. P. F. Quigley, Department of Commerce and Agriculture, and Mr. P. C. Cousins, Department of Agriculture):—

(a) *Jarrah*—

(1) Where only two paper-liners were used, in the majority of cases sawdust and small chips of wood were found adhering to the uncovered edges of the butter.

(2) In 70 per cent. of the boxes tipped, the paper-liners adhered to the casein spray surfaces.

Butter from the Watsonia factory was machine-packed, three dry paper-liners completely covering the butter. This butter left the box cleanly.

(3) In three instances patches of sap-stain were found on paper-liners.

(b) *Hoop pine*—

(1) The inner side of the three-ply ends were comprised of a variety of timbers, some of which, although sprayed, imparted objectionable taints in varying degrees to the butter.

On the whole, the degree of taint found in butter packed in jarrah boxes compared favourably with that found in butter packed in hoop pine, three-ply ends other than hoop pine excluded.

Wetted paper liners and extraneous moisture was probably the cause of the bulk of the taint found in the butter packed in jarrah boxes.

EXPERIMENT—JARRAH BOXES.

No.	Code Mark.	Pine.	Jarrah.	Grade.	Degree of Wood Taint.	
					Hoop Pine.	Jarrah.
	911					
1	2–1–32–20–12	1	1	40	Ends strong	One side strong.
2	2–2–29–20–12	15	14	40	Ends medium	One side medium.
3	3–1–31–20–12	15	16	40	Ends strong	One side strong, one medium.
4	3–2–27–20–12	14	13	40	Ends medium	One side slight.
5	4–1–20–20–12	10	10	40	Ends medium	Trace.
6	2–1–35–21–12	8	7	41	Ends slight	Sides slight.
7	2–2–31–21–12	9	10	41	One side slight	One side slight.
8	3–1–31–21–12	15	16	40	One side and one end medium	Bottom slight.
9	3–2–30–21–12	15	15	40	Free	One side medium.
10	4–1–32–21–12	16	16	40	One end fishy, one medium	Free.
11	2–1–35–22–12	5	6	40	Two ends slight	Free.
12	2–2–32–22–12	13	13	40	Two ends medium	One side medium.
13	3–1–27–22–12	1	....	39	Bleached bottom very strong	No duplicate.
14	3–2–24–22–12	10	10	39	Free	Bottom slight.
15	2–1–33–23–12	4	5	40	One end strong	One end slight.
16	2–2–29–23–12	15	14	40	Two ends strong	Free.
17	2–1–43–24–12	9	10	40	Trace all round	One bottom corner wet, and taint strong.
18	2–2–32–24–12	16	16	40	Sides slight, one end medium, one strong	One side slight.
19	3–1–23–24–12	1	1	40	One side medium, ends slight	Free.
20	3–1–31–25–12	16	15	40	Ends one strong, one medium	Free.
21	3–2–28–25–12	14	14	40	Free	Free.
22	4–1–30–25–12	15	15	40	One end strong	One side slight.
23	4–2–30–25–12	15	15	40	One end mould spores and medium	Free.
24	3–1–25–27–12	8	8	40	One end medium	Bottom slight.
25	3–2–23–27–12	12	11	40	One end and bottom strong	Free.
26	2–1–19–28–12	4	5	38	One end strong	One side medium.
27	2–2–32–28–12	16	16	38	Both ends and bottom strong	Free.
	916					
28	7–1–22–11–12	....	22	38	No hoop pine	Free.
29	7–2–28–11–12	....	28	38	No hoop pine	Free.
30	6–1–25–15–12	....	25	39	No hoop pine	Free.
31	6–2–25–15–12	....	25	39	No hoop pine	Free.
32	6–1–25– 5– 1	....	25	36	No hoop pine	Free.
33	6–2–25– 5– 1	....	25	37	No hoop pine	One side medium.
34	3–1–24– 6– 1	....	24	38	No hoop pine	Free.
35	3–2–26– 6– 1	....	26	38	No hoop pine	One side medium.
	903					
36	2–1–40–15–1	....	....	36	Off flavours masking any wood	taint which might be present.
	906					
37	2–1–24–18–12	....	....	40	Both ends strong	Slight.
38	2–2–20–18–12	....	....	39	One end and one side strong	Medium.
39	2–3–11–18–12	....	....	40	End medium	Faint.
	908					
40	2–1–22–28–12	....	....	Pastry	Off flavours too pronounced to	detect wood taint, if any.
41	1–2–21–30–12	....	....	Pastry	Off flavours too pronounced to	detect wood taint, if any.

The Utilisation of Cereals for Green Fodder.

H. G. CARISS, Agricultural Adviser.

IN the early days of the development of the Wheat Belt in Western Australia, little attention was actually necessary, or given, to the growing of cereal crops for grazing purposes.

With the greater diversification of wheat belt agriculture, with increasing numbers of sheep being carried and more attention being given to the raising of lambs for export, the need for the provision of green grazing became intensified.

The increase in the use of cereal crops for green fodder purposes from under 100,000 acres in 1930-31 to approximately 400,000 in 1943-44 was discussed in a previous issue of this Journal (Thomas, Millington and Cariss—September, 1944). In addition to the areas used solely for green grazing there are, of course, quite large acreages which may be grazed once, early in the season, and allowed to mature for grain or hay. Actual figures for such areas are, however, not available.

The Place of Cereal Fodder Crops in the Farm Crop Rotation.

A suitable cereal crop grown for green fodder has a definite and important place in the farm rotation. Some farmers make a regular practice of sowing special areas each year with considerable financial benefit.

The seeding of these crops takes place prior to the commencement of the main cropping programme and therefore causes no interruption in that direction.

Where wheat cropping is reduced there is still the necessity in many cases, to continue with the periodical cultivation of the paddocks and the sowing of cereal fodder crops, such as oats or barley, is most advantageous for this purpose.

Quite a good practice is to graze such a fodder crop early, whilst the natural pasture in the other paddocks is establishing itself and then shut up the cereal paddocks and allow them to recover and mature for grain or hay or if not required for either of these purposes, the stock can be turned in to harvest the area themselves.

Where lambs are being bred for export, the provision of green fodder crops is an essential item. With careful management, it may be possible, if seasonal conditions permit, to utilise the same crop, especially if oats are used, for "steaming up" the in-lamb ewes in the Autumn (Underwood and Shier, 1942) and then depasture the lambing ewes and lambs on the area on several occasions until late July or early August, after which the paddocks can be shut up and the crop allowed to mature for grain. Later in the season, the crop can be utilised for "flushing" the ewes prior to mating—(Underwood and Shier, 1941).

The use of cereal rye for green feed purposes is not usually recommended in preference to oats or barley. This cereal provides excellent early green feed; but it is not normally utilised where recovery for a grain crop is desired. Rye, however, can be used to assist in soil erosion (wind drift) control and yet permit some use being made of the area during the winter months. Where erosion control is being practised, the grazing must not be extended too long as a good stand of rye is desired to assist during the summer months in anchoring the soil.

Green fodder crops can be used to fit in with many farm crop rotations, one important factor to remember is that by depasturing the stock on the paddocks, the fertility of the area is improved. With grain and hay crops, the soil reservoir of plan nutrients is depleted whereas with grazing crops, the major portion (approximately 70 per cent.) taken up by the plants is returned by the grazing stock.

Cereal Crops for Grazing.

Cereal crops utilised for grazing may either be:—

(i) Sown definitely for that purpose.

(ii) Crops which have been seeded early and have become too forward in growth for the period of the year.

(1) *Crops Sown Specifically for Green Grazing.*

These crops are primarily sown with the specific purpose in view of the green growth providing an early green bite for sheep. Such crops normally provide adequate green feed much earlier than the natural pasture, the cereals being more rapid and erect in their early growth in comparison. They may be grazed outright or allowed to mature later for grain or hay.

(2) *Crops Forward in Growth.*

In some seasons, it is possible for farmers to commence seeding operations somewhat earlier than usual, and should satisfactory rains and growing conditions follow there is always the possibility of rather too forward crops resulting.

Where crop growth becomes too forward early in the growing season, it is doubtful whether any but poor to medium grain yields will be obtained. Forward crops are always more liable to considerable lodging and damage by such diseases as septoria.

Cultivation of Green Cereal Fodder Crops.

Cereal crops intended for green grazing can be sown either on the stubble or on a fallowed area specially set aside for the purpose.

Sowing on the stubble is quite widely practised and could be used even more so to considerable advantage. The most suitable implement to use for seeding is a disc cultivating plough equipped with a seed box attachment. If a tyned implement is used and the straw is rather thick, then trouble may result through blocking of the floats by straw. Burning off of the stubble is sometimes practised but this is not recommended. Heavy stocking of the area during the summer will assist in reducing the stubble and enable the discs to make a reasonable seed bed. Particularly where tractor power is available the sowing of oats on the stubble should become routine practice on farms.

Seeding on a fallowed area is similar to that for any other cereal crop. In regard to such areas, it is quite a sound practice to utilise one or more paddocks for several years in succession, the method adopted being to fallow one year, seed early the following Autumn and then graze the paddock bare, using two or three grazing periods, then fallow the land again in early Spring ready for the following Autumn.

The seeding rate to be used is dependent upon whether the crop is to be grazed right out or is to be allowed to recover for grain or hay. If it is to be grazed out, then one bushel per acre should be sufficient; but where recovery is desired, the rate should be increased by say 50 per cent. Some users advocate 40-50 lb. of oats when grazed only and 70-80 lb. when recovery is desired.

Fertiliser requirements vary depending upon the previous history of the paddocks concerned. It is not recommended that no superphosphate be applied when the crop is sown on the stubble though, under normal fertiliser usage, there is considerable residual effect from the previous year's applications. In such cases, it is suggested that the application be reduced somewhat below normal. When sown on the fallow, the usual application for cereal crops should be used.

Grazing Management.

The management of the grazing of the crop is all important as, particularly where recovery for grain is desired, it is essential that the area concerned be grazed in a proper manner.

Firstly, a knowledge of the growth habits of the plant must be acquired. The salient points on this subject were set out in a previous issue of this Journal (Thomas and Millington, March, 1942) and for convenience are repeated here.

"The management of cereals for grazing and recovery is based on an appreciation of the different stages or phases in the development of the plant. The first stage above ground is the development of foliage leaves which are the site of manufacture and to some extent, storage, of food material used for aerial and particularly root growth. About the base of the plant a number of buds are formed, each of which carries as its apex the minute cells from which the ear and seeds develop. The second phase comprises the elongation of the base of each bud to give a stalk carrying the ear. The removal of the ear bearing shoots seriously reduces the grain yield, so that the aim in management is to confine grazing to the leafy vegetative phase and to avoid the injury of reproductive shoots."

Fig. 1.
Oat plant in grassy stage in which condition it may be grazed safely.

The effect of grazing on cereal plants has been studied by various workers. In Victoria, Forster and Vasey (1931) made observations during the carrying out of a crop census between 1927 and 1931. The accompanying figures (Figs. 1-5) taken from that paper, illustrate the results of judicious and injudicious grazing. Forster and Vasey strongly stressed that the plant should not be grazed beyond the date when the critical change in growth occurs. This critical change occurs when the plant growth changes from the vegetative or grassy to the reproductive or stemmy.

An indication of the behaviour of a typical general purpose oat variety grazed under wheat belt conditions can be obtained from study of the results of an experiment carried out at the Merredin Research Station and reported on in the March, 1944, issue of this Journal (Thomas and Millington, 1944).

The procedure in this experiment was to cut four different plots at fortnightly intervals from the end of June, when the crop was six inches high, until it matured in October. The results of the experiment are illustrated in the accompanying graph reprinted from that article. (Graph Fig. 6.)

The period during which grazing can be carried out is dependent upon whether recovery for hay or grain is required and varies, of course, between districts and is dependent in any given year upon the seasonal conditions. Further, the number of grazings during the period also varies, for instance, under wheat belt conditions, exemplified by Merredin Research Station, one grazing and not later than the end of July, gives optimum results. Under most favourable conditions two grazings can be taken but again the period should not be extended beyond July. Under more favourable rainfall conditions, such as at Avondale Research Station and Chapman, two or more grazings can be taken, dependent upon growing conditions.

Fig. 2.
Oat plant showing typical recovery after judicious early grazing.

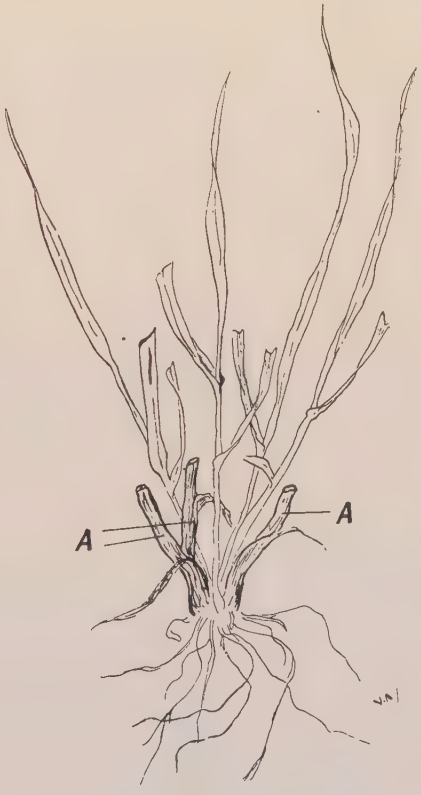


Fig. 3.
Oat plant which has been grazed too late in season.
(Note dying bases of the primary stools (a) with the weaker secondary stools forced into growth.)

When feeding off a crop, it is essential that each grazing should occupy only a short period and a large flock of sheep be used. If the feeding off is slow, the sheep will tend to exercise selective grazing, eating off the new shoots as they appear in preference to the older ones. The rapid feeding off is particularly important where an advanced crop, intended for grain, is being fed off. The efficiency of the utilisation of grazing crops is considerably increased where reasonably small paddocks are available, say 50 or 100 acre units, or in the case of larger paddocks, the use of temporary fencing. Under either of these systems, rotational grazing can be practised with maximum efficiency.

Fig. 4.
Oat plant showing vigorous secondary stooling (b), similar to the early growth in dense wheat crops which it is desirable to check.

Fig. 5.
Oat plant showing typical recovery after judicious grazing of such a plant as that in Fig. 4. (Note secondary stools definitely checked and increased dominance of important primary stools.)

Further points to be considered are—

(1) Sheep should not be turned in on an empty stomach.

(2) If from poor pasture then only allow the sheep on for a few hours for the first day or so.

In the case of both (1) and (2) digestive troubles may result if care is not exercised.

(3) Sheep should not be turned into a paddock when it is in a very wet condition, pugging of the soil may result with a detrimental effect on the plant recovery.

(4) Careful harrowing of the area after the sheep have been removed is usually beneficial but care must be exercised that the plants are not excessively damaged or recovery will be affected. Greater care must usually be taken with oats than with wheat.

With regard to harrowing the crop, it is pointed out that the damage to the crop is never as great as it might appear from the look of the harrows during the operation.

(5) Crops intended for grain should not be grazed unless absolutely necessary, but in the event of such a necessity arising, then the grazing must be rapid and over a very short period to permit of the maximum period for recovery.

Cereal Varieties for Grazing.

Experimental evidence and other observations have shown that there is a marked difference in the capacity of certain of the cereals to recover from grazing and give reasonable grain or hay returns. Further, individual varieties of each cereal type recover better than others. Barley is usually better than oats and rye, which are better than wheat. Varieties which have good-stooling capacity are usually better than the poorer stooling types.

Over a number of years small scale cutting trials have been conducted at several of the Research Stations and of late years, these trials have been expanded to larger scale grazing and recovery trials. The results of these latter trials have been published in this Journal from time to time and for convenience of reference are summarised in this paper. Wheat is, at present, the least satisfactory of the cereals, and was not included in any of the large scale trials. A grazing trial using wheat has, however, been initiated this season.

Table I.

SUMMARY OF GRAZING AND RECOVERY TRIAL YIELDS.

Variety.	Maturity.	Avondale 1941–43.				Merredin 1943–44.	
		Dry Matter Yield :			Grain Yield.	Dry Matter Yield.	Grain Yield.
		First Grazing.	Second Grazing.	Total.			
		cwt. per acre.	cwt. per acre.	cwt. per acre.	bus. per acre.	cwt. per acre.	bus. per acre.
Dale	Late Midseason	10·9	7·6	18·5	21·7	...	...
Fulghum ...	Early Midseason	10·1	...	18·1	19·1	3·2	19·2
Ballidu ...	Early	10·1	7·3	17·4	23·0	4·1	18·7
Mulga	Early	*8·6	8·2	16·8	11·2	4·0	14·7
Wongan ...	Very Early ...	*10·5	9·3	19·8	12·5	4·7	16·0
Guyra	Midseason ...	†13·6	3·9	17·5	22·1	...	...
Atlas Barley ...	Early	‡16·1	8·3	24·4	§18·0	...	...

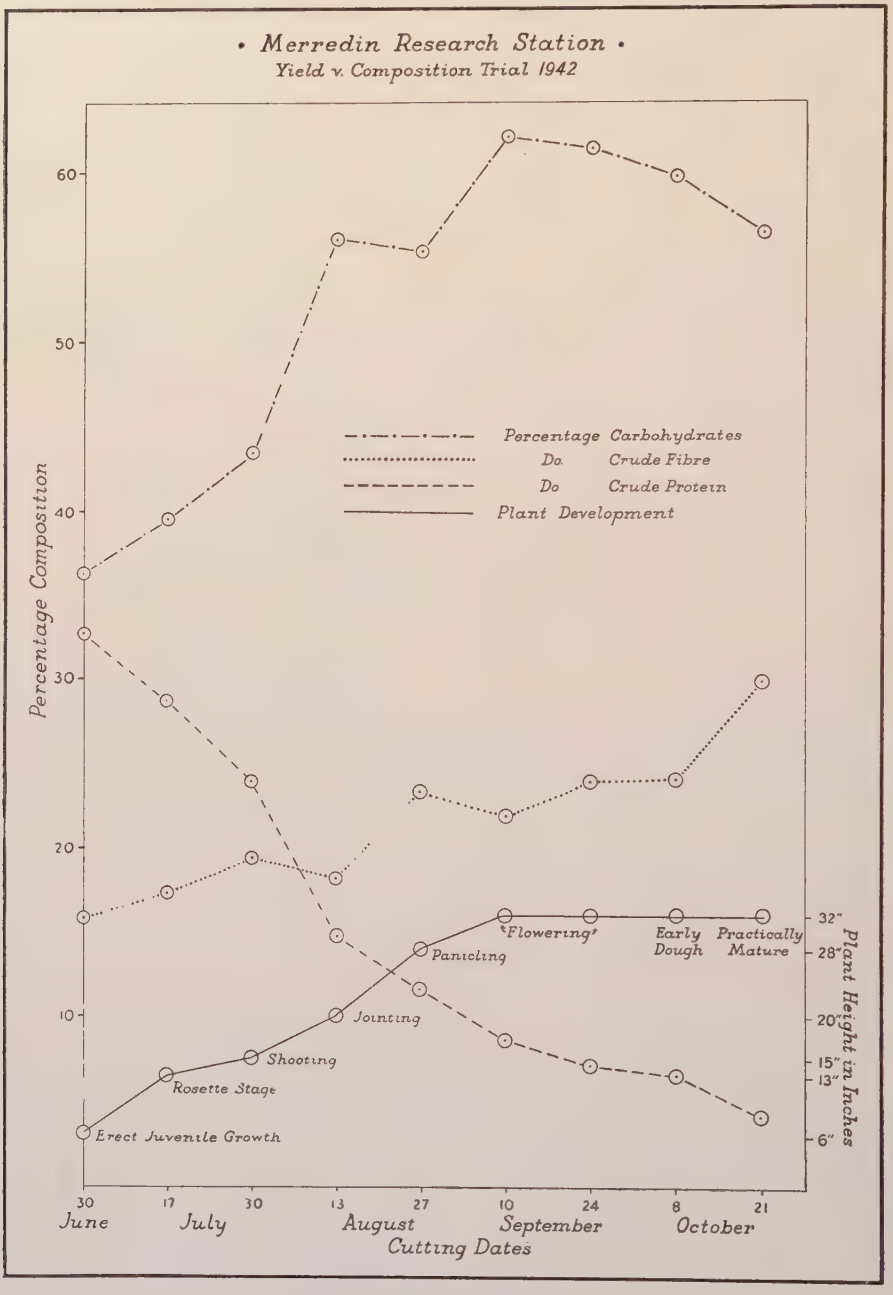
* 1941–42 only. † 1943 only. ‡ 1942–43 only. § 50 lb. per bushel.

Recommended cereal varieties are Fulghum, Dale Ballidu and Wongan oats and Atlas barley. Rye is recommended for soil types unsuitable for the other cereals and where soil drift is liable to occur.

Nutritive Value of Green Cereal Crops.

In addition to providing a green bite when other pastures are not available, the nutritive value of green cereal crops is very high.

The provision, whenever possible, of such crops for the use of the in-lamb ewe during the last six weeks of the gestation period and after lambing, is therefore of considerable importance. The utilisation of a young green crop of Atlas barley in the control and prevention of pregnancy toxaemia was strikingly shown by Underwood and Shier in their studies in sheep husbandry, carried out at the Avondale Research Station in 1942.



The nutritive value of the young growth can be readily appreciated from a study of the chemical analysis of the cuttings from the grazing and recovery trials at Avondale and Merredin Research Stations. (Table II.) The alteration in the chemical composition of the oat plant during growth is also shown by the results of the analysis of the progressive cuts from the trial conducted at Merredin in 1942, and shown graphically above.

TABLE II.

COMPOSITION OF GRAZINGS FROM GRAZING AND RECOVERY TRIALS.

Avondale Research Station.

Variety.	Crude Protein.		Crude Fibre.		Carbohydrates.	
	Grazed :		Grazed :		Grazed :	
	23–6–41	24–7–41	23–6–41	24–7–41	23–6–41	24–7–41
Wongan	23·9	21·1	24·1	24·6	35·3	39·7
Fulghum	28·1	21·6	20·5	22·1	33·1	39·8
Mulga	25·5	23·0	21·2	22·6	36·1	38·8
Ballidu	24·2	22·2	20·6	22·1	35·5	41·6
Dale	25·1	23·6	20·4	21·2	34·5	39·6
	Grazed :		Grazed :		Grazed :	
	10–6–43	7–7–43	10–6–43	7–7–43	10–6–43	7–7–43
Guyra	26·6	22·5	21·3	18·5	34·82	42·13
Atlas Barley	24·5	20·3	23·5	22·8	32·35	37·59

Merredin Research Station.

	Grazed :		Grazed :		Grazed :	
	5–7–43	24–7–44	5–7–43	24–7–44	5–7–43	24–7–44
Wongan	29·1	24·1	17·9	20·6	35·76	Not
Fulghum	32·2	27·3	16·2	19·7	34·40	De-
Ballidu	30·1	26·2	17·9	17·8	34·85	ter-
Mulga	32·8	27·5	18·6	20·9	31·28	mined
	Grazed :		Grazed :		Grazed :	
	18–7–41	8–8–41	18–7–41	28–8–41	18–7–41	8–8–41
Atlas Barley	34·5	33·3	18·2	17·2	28·8	29·1
Slav. Rye	40·1	35·4	16·9	17·9	28·7	27·5
Fulghum Oats ...	36·6	32·6	20·5	24·2	27·6	26·6

*Common Fodders for Comparison.**

	%	%	%
Good Cereal Hay ...	5	30	57
Wheat Grain	13	3	80
Oat Grain	10	13	66
Barley Grain	12	5	77
Rye Grain	12	3	80

* Approximate figures only.

Summary.

The cultivation of cereals as green fodder crops is discussed and the need for their greater use in the farm crop rotation stressed.

By the efficient use of such crops the carrying capacity of a property can be increased and maintained at a much higher level.

Green cereal fodder crops are either sown specifically for that purpose or may be crops too forward in growth for the period of the year.

Cereal crops sown specifically for green fodder may be grazed right out or grazed on one or two occasions, according to circumstances, and then allowed to mature for grain or hay.

When recovery for grain is required, it is essential that the grazing be not prolonged into the critical change period of growth from the grassy to the reproductive. The result of judicious and injudicious grazing is illustrated.

Efficient management is essential for optimum utilisation of the areas. By restricting the grazed area to comparatively small units and using large numbers of stock for short periods, the maximum amount of material can be obtained.

It is pointed out that the different cereals, and different varieties of each, vary in their capacity to be grazed. Generally speaking the earlier maturing, poorer stooling varieties give the greatest bulk early in the season and the later maturing good stooling varieties later in the season. A judicious use of both types should ensure maximum green fodder.

Recommendations regarding varieties are made and results of trials with these given.

The importance of the nutritive value of the young green herbage is stressed and its usefulness particularly to in-lamb and lambing ewes pointed out.

ACKNOWLEDGMENTS.

Grateful acknowledgment is made to the Superintendent of Wheat Farming (Mr. I. Thomas), the Plant Geneticist (Mr. A. J. Millington) and other officers for much helpful advice and criticism in the preparation of this paper.

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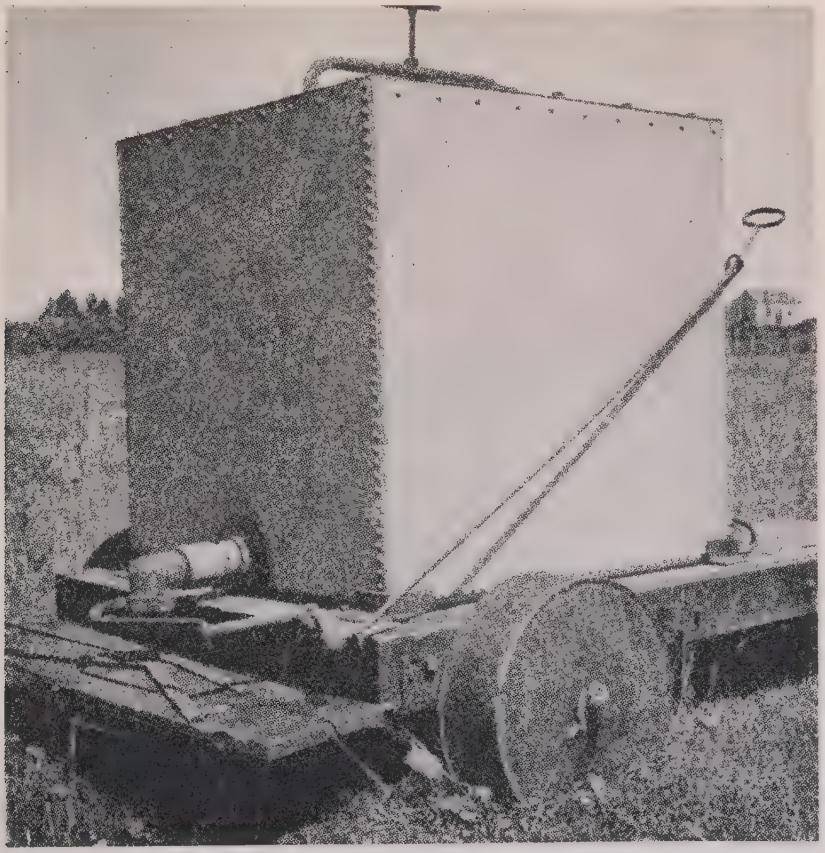
Liquid Manure on Dairy Farms.

N. McKeown, Agricultural Adviser.

GENERAL information regarding the nature of farmyard manure and its utilisation has been supplied in articles in two previous issues of the Journal of the Department of Agriculture. In the second of these articles brief reference is made to the conservation and distribution on the paddocks of liquid excrement and shed washings in addition to the solid excrement. In this article it is intended to deal at greater length with this simple and practical method of increasing the carrying capacity of the small holding.

It is on such small properties, subject to a system of intensive farming, that conservation and utilisation of excrement from all sources, cowyard, piggery and stable, can be turned to such good account to improve the soil and increase returns. Formerly such utilisation of stock excrement has been limited to the harrowing of pastures at shorter or longer intervals to spread the droppings, to the heaping up of dung in yards, or, at best, storage in concrete pits, to await a seasonal slackening of work to permit of removal to and spreading on the paddocks. When these routine practices are carried out at regular inter-



The most common type of distributor is the square iron tank fitted to a low trolley with sledge runners in front.

vals, they are, in themselves, quite laudable achievements, but too often dung is left to promote rank growth of isolated patches in the paddock and thus reduce carrying capacity, and loose, open dung heaps are built close to milking sheds to be trodden about by stock and constitute a potential source of contamination of milk in the dry summer months. In addition to these objectionable features, such methods cause great loss of fertilising ingredients from the manure itself.

An efficient and practical method of removing animal droppings and shed washings to pasture and cropping paddocks has been evolved of recent years, and adopted with great success by many New Zealand farmers (1). A cement washed or concrete lined tank holding approximately 1,000-5,000 gallons is constructed at a suitable distance from the sheds. The dung and urine are washed into this with just enough water to clean the shed, provision usually being made to divert excess rain water away from the sump. The latter is emptied at regular intervals by pumping the liquid, either by electric or hand pump, into a tank mounted on a sledge or motor truck. To facilitate cleaning out the intake of the pump the sump is usually made fairly shallow. The distributing tank may be of either wood or metal, but due to the corrosive action of the liquid manure, the inside of an iron tank should be protected and a brass tap provided for the outlet of the tank.

The types of distributing apparatus are numerous, depending on finance, labour and the amount of material available.

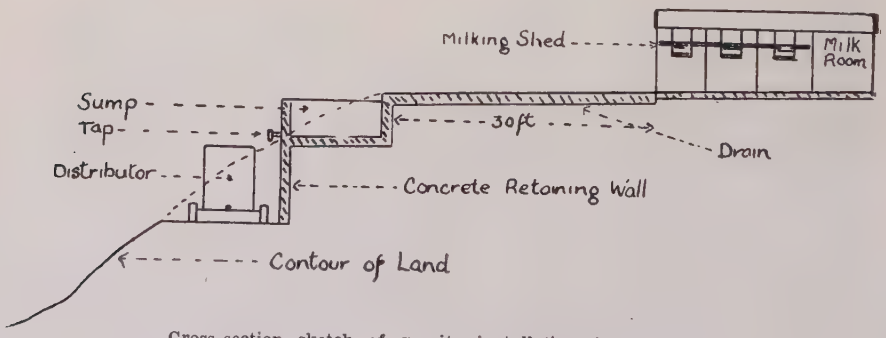
Cost of Outfit.

The following details relative to costs were quoted by Mr. A. G. Elliott of the New Zealand Department of Agriculture. (1)

For farmers milking up to 50 cows the following equipment has proved very satisfactory:

Sump, cement lined, 5ft. x 10ft. x 3ft. (own labour)	£7 10 0
Hand Pump, 6ft.	6 0 0
200-gall. tank on sledge, complete	23 0 0
Total approximate cost	£36 10 0

Provided a cut-off is installed to divert extra rain water, this sump can be conveniently emptied once a week. Where the sump can be built to permit of gravitation into the tank, much time and labour can be saved. This method has proved increasingly popular of recent years.



Cross-section sketch of gravity installation (not to scale).

For larger herds, or where an existing piggery is run in conjunction with dairying activities, the following more expensive equipment is justified:

Sump, 10ft. x 12ft. x 7ft. deep	£11	0	0
Electric pump and 1½ h.p. motor, complete	38	0	0
400-gallon tank and fittings	10	0	0
Total approximate cost	£59	0	0

One of the virtues of the larger plant is that material can be allowed to accumulate if necessary, and most recent information indicates that if liquid manure is stored for 10-14 days quicker and better results are obtained. Another advantage is that the larger tank is transported on a motor truck and by this means allied with the use of an electric pump, the material can be handled more expeditiously and labour costs reduced accordingly.

A distributor mounted on a motor lorry.

A pertinent question at this juncture would be, "But what material gain may be expected from the use of liquid manure apart from the improved sanitary condition of the shed surroundings?" To answer this question the N.Z. Department of Agriculture made arrangements with two farmers to keep careful records of

the quantities of liquid manure utilised during one year, and monthly samples were taken from the sump and analysed by the Department chemist (2). From these figures the equivalent manurial values in well known chemical fertilisers were assessed and are shown in the following tables:—

Month.	No. of Cows.	Gals. of Manure.	Sulphate of Ammonia.	Dried Blood.	Super.	30% Potash.	Lime.	Magnesium Sulphate.	Total.
			lb.	lb.	lb.	lb.	lb.	lb.	lb.
No. 1 Farm.									
August	54	3,000	106	340	57	84	62	59	602
September	55	5,000	176	566	95	140	102	97	1,000
October	55	4,000	141	453	76	112	82	78	801
November	55	5,000	170	600	106	168	101	111	1,086
December	55	5,000	75	311	53	91	60	68	583
January	50	5,000	151	354	54	100	61	85	654
February	50	4,200	42	379	74	107	88	102	750
March	50	5,500	48	312	67	76	36	81	572
April	50	4,500	108	520	118	124	106	96	964
May	30	4,800	36	137	28	54	30	41	290
Totals	....	46,000	1,053	3,972	728	1,056	728	818	7,302
No. 2 Farm.									
September	65	3,400	137	366	42	134	30	48	620
October	71	6,000	241	646	74	237	52	84	1,093
November	72	6,000	224	635	91	275	59	89	1,149
December	71	6,500	196	434	31	219	28	57	769
January	71	5,300	175	390	35	182	44	78	729
February	71	4,000	74	326	23	166	30	50	595
March	68	6,400	99	278	32	93	18	54	475
April	65	6,000	224	606	87	197	69	90	1,049
May	45	5,000	141	305	25	130	21	46	527
Totals	....	48,600	1,511	3,986	440	1,633	351	596	7,006

Farm No. 1 had been heavily top-dressed with lime and phosphates for a number of years, while farm No. 2 had been less liberally treated with these fertilisers, a circumstance which is clearly illustrated in the tables, and shows that the quality of the pasturage is reflected in the quality of the manure produced therefrom.

On farm No. 1 the sump held just over 5,000 gallons and was emptied once a month. With the distributor employed, labour was a minor consideration as the complete operation took only a few hours each month. At an average application of 4,000 gallons per acre, some 11 acres of the farm received a dressing containing on an average the equivalent of nearly 1 cwt. sulphate of ammonia, over ½ cwt. of superphosphate, a little less than 1 cwt. of 30% potash, more than ½ cwt. of lime and ¾ cwt. magnesium sulphate.

On farm No. 2, due to the greater average distance from the pasture to the milking shed, much more of the droppings were deposited on the way to the shed. On this farm about 12 acres were top-dressed at the rate of 4,000 gallons per acre, resulting in an average distribution of over 1 cwt. sulphate of ammonia, about 36 lb. superphosphate, 1¼ cwt. 30% potash, 30 lb. lime and 50 lb. magnesium sulphate per acre.

From these figures supplementary applications of super and lime appear necessary, but on application, shed washings give immediate results and the residual benefit is claimed to be apparent for two years. It is further claimed that the small quantities of lime and phosphate contained in the liquid manure are very readily available and that applications of liquid manure once in three years would maintain the improvement.

To emphasise the fact that farmers who adopted the practice of liquid manuring were not wasting time and money, a cash value based on the cost of fertilisers was worked out for the liquid manure and balanced against the cost of the plant. It was shown that on the average for the 126 cows on the two farms under observation each 50 cows would produce per annum the equivalent of:—

½ ton sulphate of ammonia	£9	5	0
½ ton 30% potash	7	14	4
4 cwt. superphosphate	1	0	8
4 cwt. lime		18	0
	£18	18	0

For the purpose of local application the above values of fertilisers are based on Western Australian prices.

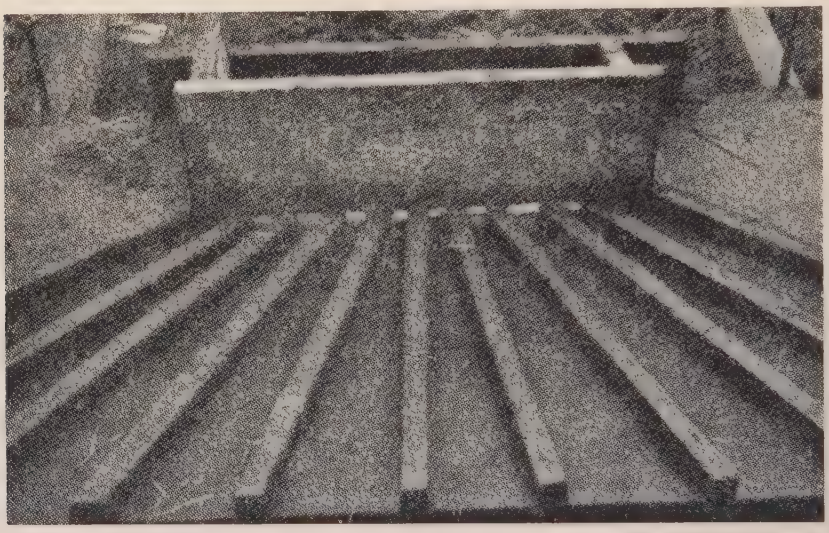
The cost of the sump and distributor on each of these farms was approximately £30, and the labour in distributing the material was about four hours per month. The cost of plant and labour would adequately be met in two seasons, leaving cost of labour as the only charge in subsequent seasons.

Though the fertiliser value for 50 cows per year in itself does not appear to be high, considered for many cows over an entire State the gain would be very appreciable. Furthermore, definite benefits accrue from the use of liquid

A measured growth of rye grass and clover in two months.

manure which do not accompany the use of its equivalent in artificial fertilisers. Not only is the growth of grasses greatly stimulated but also that of clovers, a surprising fact in view of the high nitrogen content of the manure.

The response of pastures to liquid manure is very rapid and provided the dressing is not too heavy no distasteful rank growth results, and in showery weather stock may be grazed over the treated area a day or two following application. Two hundred gallons to approximately 600 sq. yards has been found



A spreader for use on lorry or wagon where tap has vertical delivery.

to be a suitable dressing of washings of average concentration, and an efficient agitating system in the distributing tank helps greatly to ensure against fouling of pasture by preventing the heavier sediment sinking to the bottom.

Examples of the Use of Liquid Manure.

Two typical examples may be cited from the Taranaki district of New Zealand to show the improvement in production which may be achieved by the consistent use of liquid manure (1).

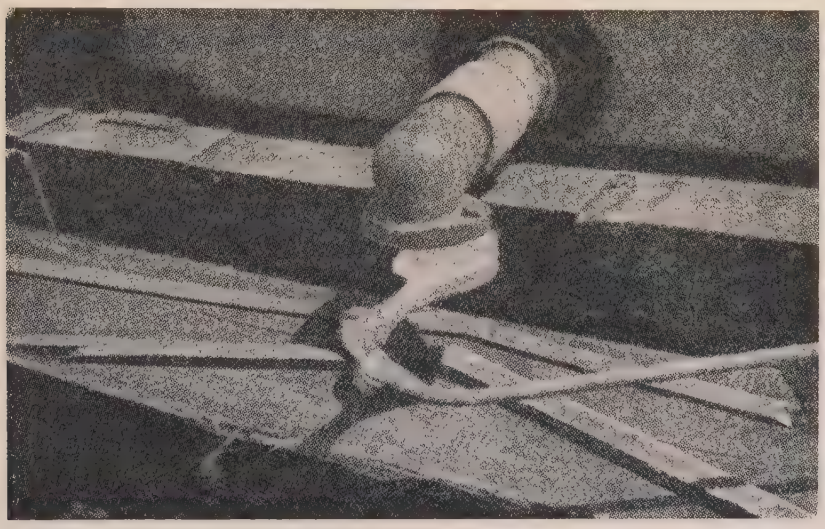
Farm A.

On this farm a double sump has been built to deal with both pig and cow shed washings. Each sump, 16ft. x 8ft. x 3ft. 6in. deep will hold approximately 15 tons, the material from each source being kept separate. In a third chamber 3ft. by 2ft. the material from each sump can be mixed through outlets, the surge providing the mixing so essential for even distribution. It has been proved that the residue from the cow sheds lasts longer than that from the sties so a half and half mixture is now applied with very good results. Butterfat production had been increased annually up to 1938 by 1,000lb., but after installing the plant for distributing liquid manure returns rose by more than 2,000lb. for the season.

Farm B.

A sump was not built on this farm, the shed washings and manure being conveyed direct to the tank cart which was emptied daily. Butterfat production on this farm has been increased from 11,000 to 42,000 lb. in seven years by a combination of pasture harrowing, surface sowing and top-dressing, and the use of liquid manure.

It is not expected that with the present shortage of labour and material supplies many farmers will be able immediately to adopt the system of liquid manuring which has proved so successful in New Zealand, but it is unnecessary



Spreader board for use with trolley-sledge above.

to urge, after 5½ years of war, that any avenue which offers the possibility of supplementing the small available quantities of artificial fertilisers should be given serious thought. Failing immediate adoption of what appears to be a very practical method of achieving such a result, most dairy farmers would be well advised to contemplate the possibility of installing a plant as soon as the handicaps imposed by war-time conditions are removed. In this manner farms which are now feeling the pinch of successive years of fertiliser rationing will be enabled more rapidly to build up soil fertility in post-war years the better to face economic conditions which may be less kind to the farmer than is the case at present.

SUMMARY.

1. Application of liquid manure affords a method of coping with waste substances from the milking shed and piggery and converting them to very profitable use.
2. Feed does not become rank and unpalatable. Growth is well controlled and in showery weather cows will graze the treated area very shortly after application.
3. The usual applications of artificial fertilisers are still necessary to maintain a balanced growth of pasture, but the flush of feed and the residual effect following liquid manuring is very considerable.

4. Based on data supplied by many farmers in New Zealand, the installation of plants on farms of suitable contour in the dairy belt of W.A. should prove a profitable investment. If this cannot be done in the near future, it is suggested that the project be kept in mind for a later date.

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Blood Testing for Pullorum Disease in Poultry.

E. LOVEGROVE, Poultry Adviser.

J. V. LARKIN, Veterinary Technician.

AS a result of requests received from poultry farmers three years ago that the Department should consider means whereby commercial flocks might be tested for pullorum, the infectious disease of birds caused by the micro-organism *Salmonella pullorum,* a scheme was initiated whereby flocks might be tested for this serious disease by officers of the Veterinary and Poultry Branches of the Department.

It is a tribute to the keenness of poultry farmers that the applications for testing have been greater than could be carried out by the then existing staff, which has been augmented since.

As testing proceeded, it became evident that the eradication of this disease from breeding flocks could be effected speedily; and, where poultry farmers have been willing to carry out the advice of officers in interpreting the results, the disease may be almost completely eradicated from most flocks after three periods of testing.

During last year, 1943-44, 38,349 birds were tested, the average reaction being 9.9 per cent.

During the following year to 30th June, 1945, 41,568 birds were tested, which included a considerable number of birds tested in the previous year but also a number of new flocks, and the average reaction had been reduced to 5.6 per cent.

In flocks where testing has been carried out on three occasions and which were not above the average for cleanliness when testing commenced, the number of reactors was as low as 1 per cent.

The following list of flocks which have been tested for pullorum disease by officers of the Department is made available at the request of many poultry farmers who are anxious to select breeding stock from flocks where an effort is being made to eradicate this disease.

It, however, is not intended to publish the percentage of reactors in each individual flock until these flocks have been tested on the third occasion, because the whole idea of the scheme has been to assist those breeders who are anxious to eradicate the disease by doing so without in any way jeopardising their position as breeders.

A subsidiary list is given therefore, which sets out the names of those owners who have tested their flocks and in which the percentage of reactors does not exceed 5 per cent.

It is pointed out that, although flocks may become free of pullorum disease as a result of testing, it is imperative that testing should continue at least once annually after the third test to prevent a recurrence of the disease and thereby ensure some security to those who intend purchasing breeding stock.

Name.	District.	No. of Birds.
Bell & Sons, S. A.	Kelmscott	1,315
Dolbear, G.	Mt. Helena	565†
Dempster, F.	Wanneroo	207
Harrison, R.	Scarborough	2,198
Hungerford, J. S.	Cannington	903
Jones, A. W. and A. E.	Mosman Park	113
Kirke, D.	Welshpool	1,245
Lister, W. R.	Tuart Hill	2,836
Millman, G.	Wanneroo	2,345
Neave Bros.	Pickering Brook	2,253*
Pearson, R. W.	Greenmount	1,189
Pennington, J.	Welshpool	540
Rodgers, R. A.	Forrestfield	1,693
Muresk Agricultural College	Muresk	859‡
Edwards, V. H.	Carlisle	289*
Facie, J.	Tuart Hill	190
Fischer, P.	Darlington	1,167
Foster, A. T.	South Belmont	485
Johnson, G.	Cannington	1,405
Knight, R. J.	Kenwick	630
McFadden, W.	Tuart Hill	1,842*
Magowan, C. W.	Glen Forrest	797
McIntyre & Vincent	Osborne Park	1,747
Newbold, P.	Forrestfield	303
Sears, G.	Wanneroo	867
Schwarz, I.	Gosnells	1,233
Shuttleworth, L. W.	Wanneroo	635
Smetana, P.	Tuart Hill	782*
Smith, E. J.	Tuart Hill	1,874
Stocker, M.	Roleystone	916
Sullivan, B.	Forrestfield	367
Thomas, J.	Mahogany Creek	284
Wright, A.	Carlisle	136*
Wilson, H.	South Belmont	619

* Two tests. † Three tests. ‡ Four tests.

The following producers were below 5 per cent. positive reactors on their last test:—

Muresk Agricultural College (Farm Flock).
V. H. Edwards.
J. Facie.
P. Fischer.
T. Gent.
R. Harrison.
J. Hungerford.
G. Johnson.
D. Kirke.
W. R. Lister.
W. McFadden.
C. W. Magowan.
G. Millman.
Neave Bros.
P. Newbold.
G. Sears.
I. Schwarz.
P. Smetana.
J. E. Smith.
M. Stocker.
B. Sullivan.
A. Wright.

Copper Fertilisers.

THE VALUE OF COPPER ORE IN WESTERN AUSTRALIA.

L. J. H. TEAKLE.

THE discovery of the importance of copper for the health of stock and the growth of plants has proved very important in its application to Western Australian agriculture. Serious stock disorders at Gingin, Dandarragan and Margaret River were discovered, some years ago, to be associated with the deficiency of copper. Crop failures at Dandarragan and along the south coast were found to be due to the lack of sufficient available copper in the soil. Subsequently, examples of copper deficiency affecting stock, crops and pasture have been discovered in many parts of the agricultural areas, and details have been reported in the "Journal of Agriculture."

Fortunately, the control or correction of copper deficiency is simple. Stock may be fed the copper direct, or the pastures and crops may be dressed with fertilisers containing copper, in order to increase the supply to the grazing animal. Where copper deficiency of crops and pastures affects the growth, again copper-containing fertilisers are effective.

Bluestone, which contains 25 per cent. copper, is the commonest material used for the correction of copper deficiency, either in stock licks or as a fertiliser. Since the discovery of the value of copper in Western Australia, its use as a fertiliser has increased to about 300 tons per annum. In 1943-44 the demand appeared to reach a peak, and it is estimated that, if the supply had been available, upwards of 500 tons would have been used. Unfortunately, Australian supplies were inadequate, and many farmers were disappointed. For a period, bluestone as a fertiliser had to be restricted to districts where copper deficiency was known to be most serious.

The demand in 1944-45 was expected to reach 400 or 500 tons. Reports from the agencies handling bluestone for fertiliser purposes indicate that the tonnage used was considerably less than this, and it is thought that many farmers desiring copper fertilisers may not have attempted to secure supplies owing to the shortages of the previous year. The supply position has greatly improved and, in addition to bluestone, an oxidised copper ore from the mining districts of Western Australia is available in substantial quantities. Farmers should endeavour to secure their full requirements for use on land where copper deficiency has been recognised or is suspected.

Light dressings of bluestone or other suitable copper fertilisers are very effective in Western Australia. Taking bluestone as the basis, from 5-10 lbs. per acre are usually adequate for crops and pastures, and the effect appears to last for several years. Commonly the response of subterranean clover pastures does not reach a maximum for two, or even three, seasons after the application. Just how long the effect will last has not yet been determined, although experiments have been in progress for five years. In these experiments, additional dressings of bluestone showed no advantage for four years.

Copper Ore.

The uncertainty of the supplies of bluestone in 1943-44 made it necessary to explore other sources of copper suitable for fertiliser purposes. Experiments had shown previously that copper ore of the oxidised type was just as effective as bluestone for cereals and pastures, and generally as good for vegetable crops.

Copper ore may be secured in Western Australia, and in consequence arrangements were made through the fertiliser manufacturers for a substantial tonnage to be mined and made available to farmers. Stocks have accumulated, and now amount to about 800 tons, which is equivalent in copper content to about 400 tons of bluestone, or one year's requirements.

The copper ore obtained from the mining fields is finely ground and may be made available either in a mixture with superphosphate or as straight ground ore.

The ground copper ore is cheaper, the relative wholesale rates per unit of copper being about 28s. for the ore and 36s. for the bluestone; it is not highly refined and contains small quantities of such elements as cobalt, zinc and manganese, which may be useful for stock and crops in some instances, and thus add to its value as a fertiliser; it is a local product and there are adequate supplies available for immediate use. Gingin farmers, who have suffered heavily from copper deficency in the past, have used considerable tonnages of copper ore, and generally prefer it to bluestone.

The Department of Agriculture recommends farmers on copper deficient country to use copper ore as their source of copper fertiliser. It may be applied most conveniently when mixed with superphosphate. Mixtures of copper ore and superphosphate are now on the market and may be obtained from the fertiliser manufacturers. These mixtures contain a guaranteed copper content and are the most simple means of using the copper ore. It is anticipated that farmers may be able to purchase ground copper ore as such and arrange for the mixing themselves, if they so desire.

Farmers are advised to use slightly more copper, as copper ore, than for bluestone, and it is suggested that the equivalent of 1½-3 lbs. of copper per acre be applied. The quantity of copper ore equivalent to this would be determined by the analysis of the parcels supplied, and in general would amount to 10-25 lbs. per acre.

Is Blood and Bone Manure Essential for Vegetable Growing under Perth Metropolitan Conditions?

L. T. Jones.

SUMMARY.

THERE is a prejudice amongst market gardeners in the Perth metropolitan area against the use of mineral fertilisers, or, as they are more commonly called, artificial fertilisers. The information gained from seven fertiliser experiments with vegetables in the Osborne Park and Balcatta districts during the years 1943-1945 is given as evidence to show that artificial fertilisers, when properly applied, can replace the more popular blood and bone manure.

These experiments entailed work on four types of soil, namely, acid peat and peaty sand at Osborne park, and marly peat and tuart sand at Balcatta.

It was found that on the acid peat country, blood and bone manure had definite advantages over the haphazard application of artificial fertilisers. When, however, a suitable artificial fertiliser mixture was applied, the crop yields were just as good as those obtained with blood and bone manure. The addition of minor elements has proved beneficial on this acid peat.

On the sand country, with carrots under sprinkler irrigation, it was again observed that when a suitable artificial fertiliser mixture was properly applied, results equal to that given by liberal dressings of blood and bone were obtained. The apparent success of blood and bone in this instance rests mainly with its nitrogen supply, as it suffered less from washing out than did a single application of soluble nitrogenous artificial fertiliser. This advantage was removed and equal results were obtained when the nitrogenous portion of the artificial fertiliser mixture was applied in three applications instead of one application.

The rates of application of superphosphate, nitrate of soda, or sulphate of ammonia adopted in these experiments, are not based on any previous fertiliser experiments, but represent the amounts necessary to replace the nitrogen and phosphate content of the blood and bone manure in the commercial grower's normal manurial application. Although very good results were obtained within these rigid limits, it is very likely that when further work is done on the rates of application of a well-balanced fertiliser mixture, on the best time of application of this mixture, and on methods of fertiliser placement to reduce fertiliser injury, even better crop yields would result. The proper use of artificial fertilisers will result in the more economical use of fertilisers with a consequent reduction in production costs.

INTRODUCTION.

Many local gardeners are of the opinion that vegetable crops cannot be grown under our local conditions without the liberal use of blood and bone manure. The object of this article is to show, by quoting seven fertiliser experiments with carrots, cabbages and cauliflowers, carried out in the Balcatta and Osborne Park districts by the Department of Agriculture over the last two years, that blood and bone manure is not absolutely essential and can be replaced by the appropriate artificial fertilisers when properly applied, according to the type of soil involved and the requirements of the particular crop.

It is not argued that blood and bone manure should be dispensed with. It is claimed that if the vegetable grower is prepared to study the correct use of artificial fertilisers under his special conditions, then he will find that blood and bone manure can be replaced wholly or in part by suitable artificial fertilisers, at lower cost, with as good or even better results.

The manurial methods used by local gardeners have been worked out as a result of many years of experience. In most cases, the growers have obtained fairly satisfactory results and it is significant that invariably their experience has led to the use of blood and bone in liberal amounts for both peat and sandy country.

It is not to be expected that a vegetable grower, after a lifetime of experience involving the tuning of all his methods to the liberal use of blood and bone manure, will be able to switch immediately to the use of artificial fertilisers without some risk of failures occurring at the outset. However, as his experience and skill increases, there is no reason why artificial fertilisers should not produce vegetable crops as good, or even better, than blood and bone manure.

Manurial costs under intensive vegetable growing are a minor item compared with labour costs, etc., and it is quite understandable that the average grower is loath to depart from his tried methods for the saving of a few pounds on his fertiliser bill when, by the improper use of the cheaper artificial fertilisers he may ruin his crop and load himself with a financial loss. This obvious reluctance to adopt artificial fertilisers into the manurial programmes because of past failures

must be overcome, on account of the shortage of blood and bone. These experiments were designed to show how good results may be obtained without risk of failure.

The amount of blood and bone manure at present available locally is limited and insufficient to meet the demand, and consequently has been rationed. Furthermore, it is quite a possibility that the position will not improve after the war if the demand for it expands as acreages increase, and the vegetable grower has to compete for it against the increased use of the higher grades of abattoir offal in stock and poultry feeds.

For these reasons it is advisable for the market gardener to acquaint himself with the basic facts regarding the proper use of artificial fertilisers so that he can replace blood and bone wholly or in part in his manurial methods when the need arises. Only by familiarising himself with the underlying principles and following the methods discussed in this article, will he avoid the pitfalls encountered by previous local experimenters in this field.

THE FERTILISING VALUE OF BLOOD AND BONE MANURE.

Manures and fertilisers are generally valued for their ability to supply three major constituents, namely, nitrogen, phosphate and potash, which were found by experience to be the three plant foods most likely to be the limiting factors for maximum crop growth. More or less recently, the minor elements (copper, manganese, zinc, etc.) have been found to be deficient in some special cases.

PLATE 1.

Carrots from Fertiliser Experiment 3—Shows that artificial fertilisers can replace blood and bone in the grower's manurial methods, *left to right*: (1) Grower's dressing (Treatment A); (2) Artificial fertilisers replacing grower's dressing (Treatment C); (3) Grower's dressing at half rates (Treatment B); (4) Artificial fertilisers replacing grower's dressing at half rates (Treatment D). (See Table 2.)

The value of blood and bone manure is usually judged on its nitrogen and phosphate content, as revealed by analysis. However, a sample of blood and bone used in these fertiliser experiments with vegetables was analysed for further constituents and found to contain substances which may throw some light on its more obscure benefits.

The analysis revealed as follows:—

ANALYSIS OF BLOOD AND BONE SAMPLE.

Nitrogen (N)	5.11%
Phosphoric Acid (P_2O_5)	15.69%
Potash (K_2O)	0.25%
Magnesium (Mg)	0.35%
Copper (Cu)	13 parts per million.
Manganese (Mn)	12 parts per million.
Zinc (Zn)	160 parts per million.

Nitrogen, phosphate and potash are somewhat unfamiliar terms to many growers, and their significance is better understood when we translate them into the appropriate artificial fertilisers. As a ton of blood and bone manure per acre can be taken as a very common dressing for vegetables, the plant food content of 1 ton of blood and bone is given below in the equivalent amounts of artificial fertilisers.

PLANT FOOD IN 1 TON OF BLOOD AND BONE MANURE.
EXPRESSED AS EQUIVALENT AMOUNTS OF ARTIFICIAL FERTILISERS.

Sulphate of Ammonia (20% N)	5 cwts.
or	
Nitrate of Soda (15·5% N)	6½ cwts.
Superphosphate (18% P_2O_5)	17½ cwts.
Sulphate of Potash (48% K_2O)	12 lb.
Epsom Salts (9·9% Mg)	80 lb.
Bluestone (25% Cu)	2 ozs.
Manganese Sulphate (14% Mn)	3 ozs.
Zinc Sulphate (26·4% Zn)	1 lb. 6 ozs.

The nitrogen in blood and bone, being in an organic form, is not as soluble as the corresponding nitrogenous mineral fertilisers, sulphate of ammonia or nitrate of soda. The organic form of nitrogen is released to the plant regularly over a long period by the biological processes in the soil. As will be shown later, this is the main advantage of blood and bone as a source of nitrogen on sand country.

The phosphate in bone is slow in action but its effect upon the soil will extend over several years. Plants usually benefit from an easily available supply of phosphate early in their life, and for that reason the addition of a little superphosphate to blood and bone is advisable at or about planting time.

The potash content of blood and bone is very low and under our metropolitan conditions usually needs supplementing with either muriate of potash or sulphate of potash. The majority of the fertiliser experiments with cabbages, cauliflowers and carrots on both sand and peat country, showed a benefit from the use of sulphate of potash at the rate of 2 cwts. per acre.

THE ADVANTAGES OF BLOOD AND BONE MANURE.

1. Little skill is required in its use. Large quantities may be applied with no damage to the plant.

2. The organic nitrogen it contains is released comparatively slowly and it is therefore less subject to loss by washing out than sulphate of ammonia or nitrate of soda.

3. It contains other elements besides the usual nitrogen, phosphate and potash of the so-called complete fertiliser. Some of these, such as copper, manganese, magnesium and zinc, have been mentioned previously.

4. Heavy applications can be used on certain of our peat soils where similar applications of very soluble artificial fertilisers can at times aggravate the ever-present salt problem.

THE DISADVANTAGES OF BLOOD AND BONE MANURE.

1. It is an expensive source of nitrogen, phosphate and minor elements when compared with artificial fertilisers.

2. Owing to the limited output it may at times become hard to obtain. The market gardener has to compete with stock feeders for the amount of abattoir offal available.

THE ADVANTAGES OF ARTIFICIAL FERTILISERS.

1. They are a cheap, abundant, and efficient source of plant foods.

2. Quick-acting artificial fertilisers may be applied by the skilled grower at the right stage to obtain an immediate response, and in consequence produce crop yields which are impossible with a less flexible organic manure such as blood and bone.

THE DISADVANTAGES OF ARTIFICIAL FERTILISERS.

1. More skilled handling is necessary. There is a danger of plant injury when heavy applications of soluble artificial fertilisers are placed in close proximity to seeds or the roots of seedling plants.

2. Soluble nitrogenous fertilisers are easily washed out of the soil and in some instances, unless split applications are practised, the crop will suffer from nitrogen starvation later in the season.

BLOOD AND BONE MANURE CAN BE SUCCESSFULLY REPLACED BY ARTIFICIAL FERTILISERS.

In order to obtain maximum efficiency in vegetable production with the supplies of fertiliser available, the Department of Agriculture, early in 1943, commenced a programme of experiments in collaboration with leading commercial growers in the metropolitan area. The aim of the experiments was to gather information regarding economy in fertiliser practice and the possibility of replacing blood and bone manure, at least in part, with the more easily obtainable artificial fertilisers. As potash was also in short supply, some accurate information on its value and use was needed.

In each case the grower was asked to give the formula and quantity of fertiliser which he would use if supplies were freely available. This generally amounted to 20-30 cwts. of blood and bone per acre. Whatever the mixture considered most desirable by the grower, it was adopted as the standard with which to compare other treatments in the experiment.

The market gardener prepared the land and planted the seed or seedling as for a commercial crop. The experimental layout was a randomised block arrangement with five replications of each treatment. The grower undertook to carry out all the weeding, dusting, etc., necessary. In effect, the growing conditions were identical with those of the commercial crop surrounding the experimental block, except that the fertiliser applications were different.

In the experiments carried out on the sand country, the soil had been built up with heavy applications of horse manure, fowl manure, or other organic manures and the experimental fertiliser treatments were compared as supple-

mentary to these basal manurings. On the peat country the soil had been under cultivation for many years and would therefore benefit from the residual manurial effect of all the previous crops.

RESULTS OF FERTILISER EXPERIMENTS WITH VEGETABLES.

A.—SAND COUNTRY UNDER SPRINKLER IRRIGATION.

Experiment 1—*Carrots*: *A. Pozzi, Osborne Park.*

Carrots grown on blackish grey, peaty sand situated on the edge of a peat swamp. This area had been heavily manured in the past with fowl manure and other organic manures. The grower's procedure in this case was to apply about 12 cwts. per acre of a 3 to 1 mixture of blood and bone and superphosphate in one application at thinning time. (See Appendix Table 1.)

TABLE 1.

EXPERIMENT 1.—A. POZZI, OSBORNE PARK.—CARROTS.

Harvested July, 1943 *Winter Crop.*

Treatment Details.	Yield of Carrots 1st Grade Roots.	Total Fertilisers Used. (cwts. per acre.)			
		Blood and Bone.	Super-phosphate.	Nitrate of Soda.	Sulphate of Potash.
	tons per acre.				
A. Grower's dressing of blood and bone plus super-phosphate	5·5	8·6	3·4	*Nil*	*Nil*
B. Grower's dressing at half rates	8·6	4·3	1·7	*Nil*	*Nil*
C. Artificials supplying the same amounts of nitrogen and phosphate as grower's dressing A	7·3	*Nil*	9·7	3	*Nil*
D. Treatment C at half rates	8·2	*Nil*	4·8	1·5	*Nil*
E. Artificials plus sulphate of potash	11·6	*Nil*	9·7	3	1·5
F. Artificials plus sulphate of potash with nitrate of soda in four applications	11·3	*Nil*	9·7	3 (4 app.)	1·5
G. Treatment F. at half rates	8·8	*Nil*	4·8	1·5 (4 app.)	·75
H. Grower's dressing of blood and bone plus superphosphate plus sulphate of potash	11·4	8·6	3·4	*Nil*	1·5

NOTE.—The reliability of these results is reduced by the attacks of Eel-worm in a defined patch and the influence of the washings from an adjacent manure heap which affected one end of the experiment. When these affected plots were omitted, there still remained three or four unaffected plots in each treatment on which to base the average yield.

Figure in brackets shows number of fractional applications to make total.

Remarks: *Experiment* 1—*Table* 1.

Artificial fertilisers (C and D) are as good as blood and bone (A and B). The effect of sulphate of potash at 1½ cwts. per acre is very marked (E, F and H). Applying the potash at half rates gave a poorer yield (G). Applying the nitrate of soda in four split dressings conferred no benefit. Excess nitrogen (as in treatments A and C) in the absence of adequate potash showed increased leaf growth at the expense of roots, with a consequent reduction in yield. It must be borne in mind that this area had been built up with a liberal dressing of fowl manure.

Experiments 2, 3 *and* 4—*Carrots*: *J. Arbuckle and Sons, Balcatta.*

Carrots grown on light orange "tuart" sand. The grower's pre-war procedure on this poor sand was to apply 30 cwts. per acre of blood and bone manure in three applications, plus 5 cwts. per acre of superphosphate at planting time. (See Appendix Tables 2 and 3.)

Remarks: *Experiments* 2 *and* 3—*Table* 2.

Both experiments show that artificial fertilisers can replace blood and bone for carrots on this sand. Sulphate of potash at the rate of 2 cwts. per acre gave increased yields. In the winter crop the evidence points to the necessity of maintaining a proper supply of nitrogen by applying it in a number of dressings. When all the nitrogen was applied at planting time with the winter crop (Treatment G) little more than half the crop was obtained than when this same amount was applied in three dressings (Treatment F).

In the summer crop the nitrogen supply is not so important. During the warmer months nitrate formation is more rapid and washing out of nitrates is less severe. As a result, one application of fertilisers (Treatment G) is almost as good as three applications (Treatment F).

Treatment J is interesting in respect to methods that can be used to economise in blood and bone when it is in short supply.

TABLE 2.

EXPERIMENTS 2 AND 3—J. ARBUCKLE & SONS, BALCATTA—CARROTS.

Harvested July, 1943, and January, 1944.

Treatment Details.	Yield of Carrots (1st Grade Roots).		Total Fertilisers Used. (cwts. per acre.)			
	Winter Crop.	Summer Crop.	Blood and Bone.	Super-phosphate.	Nitrate of Soda.	Sulphate of Potash.
	tons/acre.	tons/acre.				
A. Grower's dressing	12·4	18·3	30 (3)	5 (1)	*Nil*	*Nil*
B. Grower's dressing at half rates	9·9	21·2	15 (3)	2½ (1)	*Nil*	*Nil*
C. Artificials replacing grower's dressing	13·1	20·5	*Nil*	26 (3)	10 (3)	*Nil*
D. Artificials replacing grower's dressing at half rates	14·4	19·5	*Nil*	13 (3)	5 (3)	*Nil*
E. Grower's dressing plus sulphate of potash	No test	27·1	30 (3)	5 (1)	*Nil*	2 (3)
F. Artificials replacing grower's dressing plus sulphate of potash	16·2	28·0	*Nil*	26 (3)	10 (3)	2 (3)
G. Artificials plus sulphate of potash all in one application	9·8	23·4	*Nil*	26 (1)	10 (1)	2 (1)
H. Grower's dressing at half rates plus artificials at half rates	15·2	No test	15 (3)	15½ (3)	5 (3)	*Nil*
J. Grower's dressing at quarter rates plus artificials at quarter rates plus sulphate of potash	No test	27·8	7½ (3)	9¾ (3)	2½ (3)	2 (3)
Difference necessary for significance $P.O_5$	4·6	5·3	....	....	....	....

NOTE.—The numeral in brackets alongside the rates per acre of each fertiliser used, denotes the number of fractional applications to make the total.

Remarks: *Experiment* 4—*Table* 3.

The results obtained in Experiments 2 and 3 enabled a modified form of attack to be arranged to cover further aspects. The conclusions to be drawn from Table 3 are that for a winter crop of carrots on this sand—

1. Liberal applications of blood and bone were necessary (up to 30 cwt. per acre) to obtain maximum yields. Reducing the grower's application of blood and bone tended to reduce yield.

2. Blood and bone manure can be applied in one dressing at planting time, if heavy applications are used, without much decrease in yield.

3. Artificial fertilisers, if properly applied, can replace blood and bone manure and are much more efficient and cheaper.

4. High rates of artificial fertilisers were unnecessary in this experiment and in fact, it was preferable to use the lower rates. Treatment H, using one quarter of the standard rate, gave an excellent crop of carrots.

5. Treatment J is the object lesson in the wrong use of artificial fertilisers under these winter conditions. The artificial fertiliser mixture was all applied at planting time. If two subsequent side dressings, each of 1 cwt. per acre of nitrate of soda, had been given, a normal crop, with double the yield would have been obtained. Had this treatment been with a commercial crop, the financial loss from the application of all the artificial fertiliser at one time would have been in the vicinity of £150 per acre.

TABLE 3.

EXPERIMENT 4.—J. ARBUCKLE & SONS, BALCATTA.—CARROTS.

Harvested August, 1944 : *Winter Crop.*

Treatment Details.	Yield of Carrots 1st Grade Roots.	Total Fertilisers Used. (cwts. per acre.)			
		Blood and Bone.	Super-phosphate.	Nitrate of Soda.	Sulphate of Potash.
	tons/acre.				
A. No fertiliser	9·9	*Nil*	*Nil*	*Nil*	*Nil*
B. Grower's dressing plus sulphate of potash	20·2	30 (3)	5 (1)	*Nil*	2 (3)
C. Grower's dressing at half rates plus sulphate of potash	16·8	15 (3)	2½ (1)	*Nil*	2 (3)
D. Grower's dressing at quarter rates plus sulphate of potash	15·2	7½ 3)	1¼ (1)	*Nil*	2 (3)
E. Grower's dressing plus sulphate of potash in one application	18·2	30 (1)	5 (1)	*Nil*	2 (1)
F. Artificials replacing grower's dressing plus sulphate of potash	19·4	*Nil*	26 (3)	10 (3)	2 (3)
G. Artificials replacing half grower's dressing plus sulphate of potash	19·8	*Nil*	13 (3)	5 (3)	2 (3)
H. Artificials replacing quarter grower's dressing plus sulphate of potash	20·2	*Nil*	6½ (3)	2½ (3)	2 (3)
J. Artificials replacing half grower's dressing plus sulphate of potash all applied in one application	11·5	*Nil*	13 (1)	5 (1)	2 (1)
K. Artificials at half rates with superphosphate in one application and sulphate of potash and nitrate of soda in three applications	18·1	*Nil*	13 (1)	5 (3)	2 (3)
L. Artificials at half rates with superphosphate and sulphate of potash in one application and nitrate of soda in three applications	21·2	*Nil*	13 (1)	5 (3)	2 (1)
Difference necessary for significance P·05	2·8	....	....	....	....

NOTE.—The numeral in brackets alongside the rates per acre of each fertiliser used, denotes the number of fractional applications to make the total.

6. Treatment L shows that the superphosphate and sulphate of potash portions of the artificial fertiliser mixture can all be applied at planting time, and that it is only the nitrate of soda that needs to be split up and applied in a number of dressings.

A treatment was included receiving no blood and bone or artificial fertilisers during the growth of the crop. Since this ground was trenched a year ago, it had received the manure and fertiliser dressings for two previous crops. In the preparation of the land for this crop, organic manurial materials, roughly estimated at about 5 tons per acre, were cultivated into the soil as evenly as possible. On top of this preliminary treatment, the fertiliser more than doubled the yield of carrots.

B. SWAMP COUNTRY.

Experiment 5—*Cabbages*: *J. Arbuckle and Sons, Balcatta.*

Cabbages grown on dark grey, clayey, marly peat. The grower's normal practice was to apply a ton per acre of a mixture of blood and bone and superphosphate at planting time, and later two side dressings of nitrate of soda, each at the rate of 5 cwt. per acre. (See Appendix, Table 4.)

In this experiment, manganese sulphate and Epsom salts were added as a basal dressing to all the treatments to avoid complications from any possible deficiencies of these substances.

Remarks: *Experiment* 5—*Table* 4.

Artificial fertilisers (treatments C and D) gave equally as good results as the blood and bone mixture (treatments A and B). Half rates were as good as full rates. When 16 cwts. per acre of nitrate of soda were used, there was practically little difference in yield, whether it was all applied at planting time or given in three dressings. There was a very substantial response to sulphate of potash at 2 cwts. per acre (treatments F and G). There was no appreciable response to the addition of the further minor elements copper and zinc.

TABLE 4.

EXPERIMENT 5.—J. ARBUCKLE & SONS, BALCATTA.—CABBAGES.

Harvested April, 1943.

Treatment Details.	Yield of Cabbages.	Total Fertiliser Used. (cwts. per acre.)			
		Blood and Bone.	Super-phosphate.	Nitrate of Soda.	Sulphate of Potash.
	tons/acre.				
A. Grower's dressing	20·6	16¾	3½	10 (2)	*Nil*
B. Grower's dressing at half rates	19·0	8⅜	1⅝	5 (2)	*Nil*
C. Artificial fertilisers replace the grower's dressing	20·5	*Nil*	16½	15⅝ (3)	*Nil*
D. Artificial fertilisers replace grower's dressing at half rates	20·5	*Nil*	8¼	7¾ (3)	*Nil*
E. Artificials replace grower's dressing, but nitrate of soda applied in one application	19·2	*Nil*	16½	15⅝ (1)	*Nil*
F. Artificial fertilisers replace grower's dressing plus sulphate of potash at 2 cwts. per acre	29·4	*Nil*	16½	15⅝ (3)	2
G. Same as Treatment F. plus the addition of copper sulphate and zinc sulphate	30·2	*Nil*	16½	15⅝ (3)	2
Difference necessary for significance P·05	2·5	....	....	....	....

NOTE.—The numeral in brackets alongside the amount of nitrate of soda used denotes the number of fractional applications to make the total. The other fertilisers were all applied at planting time.

Experiment 6—*Cabbages*: *A. Pozzi, Osborne Park.*

Cabbages grown on a black friable peat which is moderately acidic in the surface (0-6 inches — pH = 5.7). A seasonal salt problem is in evidence on certain patches of this property during the summer months. The grower's practice was to apply 30 cwts. per acre of blood and bone at planting time, and 6 weeks after planting a side dressing of nitrate of soda at the rate of 7 cwts. per acre. (See Appendix, Table 5.)

Remarks: *Experiment* 6—*Table* 5.

The experimental cabbages were badly affected by such diseases as Club Root[1] and Black Leg[2], which would tend to mask any differences due to fertiliser treatment and make it difficult to draw any definite conclusions.

[1] and [2]: See "Vegetable Growing"—Bulletin 777, pages 60-62, for the description and control of these diseases.

The yields, as shown in Table 5, more or less record the effect of fertiliser treatment on the ability of these cabbage plants to survive fertiliser injury and plant disease under these soil conditions.

However, the treatments containing blood and bone (A and B) and the treatment containing artificial fertilisers plus a minor element mixture (G) were consistently superior in appearance during growth, and suffered least deaths from disease, etc. (3 to 4 plants in 60). Despite the many complications arising in this experiment, it can be concluded that artificial fertilisers plus a minor element mixture (Treatment G) gave just as good results as blood and bone on this acidic peat.

TABLE 5.

EXPERIMENT 6—POZZI, OSBORNE PARK—CABBAGES.

Harvested March, 1943.

Treatment Details.	Yield of Cabbages.	Number of Plants Harvested.	Total Fertiliser Used. (cwts. per acre.)			
			Blood and Bone.	Superphosphate.	Nitrate of Soda.	Sulphate of Potash.
	tons/acre.					
A. Grower's dressing	25·5	56	30	*Nil*	7 (1)	*Nil*
B. Grower's dressing at half rates	24·9	57	15	*Nil*	3½ (1)	*Nil*
C. Artificial fertilisers replace the grower's dressing	22·0	51	*Nil*	24	16 (2)	*Nil*
D. Artificial fertilisers replace grower's dressing at half rates	23·0	53	*Nil*	12	8 (2)	*Nil*
E. Artificial fertilisers replace grower's dressing but nitrate of soda all applied in one application	21·0	50	*Nil*	24	16 (1)	*Nil*
F. Artificial fertilisers replace grower's dressing plus sulphate of potash at 2 cwts. per acre	20·8	50	*Nil*	24	16 (2)	2
G. Same as treatment F plus the addition of Epsom salts, manganese sulphate, copper sulphate, and zinc sulphate	24·1	56	*Nil*	24	16 (2)	2
Difference necessary for significance $P.O_5$	4·4	....	....	....	....	....

NOTE.—The numeral in brackets alongside the total amount of nitrate of soda used denotes the number of fractional applications to make the total.

The number of planted seedlings in each treatment was 5 plots of 12 cabbages = 60 plants.

In this experiment there was no benefit from the use of sulphate of potash.

Experiment 7—Cauliflowers: A. Guelfi, Osborne Park.

Cauliflowers grown on a black friable peat, which is strongly acidic in the surface. The analysis of soil samples from eight sites in this area showed that the pH for the 0-6 inch layer ranged from 4.6 to 5.0, and for the 6-15 inch layer, from 4.8 to 5.8. There is also a seasonal salt problem. This soil is very similar to that encountered in Experiment 6. Although on the same swamp, the two properties are widely separated.

The grower's normal fertiliser application for cauliflowers on this peat soil was 30 cwt. per acre of blood and bone at planting time, plus two side dressings of nitrate of soda at 2 and 4 cwts. per acre during growth.

Owing to the uneven growth, the presence of disease, and the prolonged harvest period, it was decided not to weigh the cauliflowers produced in each treatment. The owner therefore treated the area as a commercial crop and cut the cauliflowers as they became marketable. Therefore, the number of marketable cauliflowers from each treatment, plus the observations made at regular intervals during the crop's growth constitutes the data on which are drawn the conclusions of this experiment. (See Appendix Table 6.)

TABLE 6.

EXPERIMENT 7.—A. GUELFI, OSBORNE PARK—CAULIFLOWERS.

Harvested May, 1945

Treatment Details.	80 Plants in Each Treatment.			Total Fertilisers Used. (cwts. per acre.)				
	Marketable Plants.	Plants that Died.	Plants not Marketable.	Blood and Bone.	Superphosphate.	Sulphate of Ammonia.	Sulphate of Potash.	Nitrate of Soda.
A. No fertiliser	49	9	22	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*
B. Grower's dressing	41	9	30	30	*Nil*	*Nil*	*Nil*	6
C. Artificials replacing grower's dressing	19	20	41	*Nil*	20	9	*Nil*	6
D. Grower's dressing plus sulphate of potash	61	4	15	30	*Nil*	*Nil*	2	6
E. Grower's dressing at half rates plus sulphate of potash	64	7	9	15	*Nil*	*Nil*	2	6
F. Artificials replacing grower's dressing plus sulphate of potash	65	12	3	*Nil*	20	9	2	6
G. Artificials replacing grower's dressing at half rates plus sulphate of potash	61	4	15	*Nil*	10	4½	2	6
H. Artificials plus potash plus minor element mixture containing magnesium, manganese, copper, zinc, boron, and molybdenum	62	9	9	*Nil*	20	9	2	6

Remarks: *Experiment 7—Table* 6.

The widespread occurrence of "whiptail"[3] and Rhizoctonia[4] in conjunction with a degree of salt and fertiliser injury, has accounted for the abnormally high number of deaths and non-marketable cauliflowers.

Judged from the number of marketable cauliflowers, which were generally of similar size in all treatments receiving sulphate of potash, it may be concluded that artificial fertilisers (treatments F, G, and H) can replace blood and bone manure (treatments D and E), when sulphate of potash at 2 cwts. per acre was included in both cases. The effect of sulphate of potash was outstanding, as can be seen by the effect of its omission in treatments A, B and C. Where potash is deficient an unbalanced fertiliser mixture, either as artificial fertilisers or blood and bone, can be more harmful than no fertiliser at all. Blood and bone was less harmful than artificial fertilisers in the absence of potash. (Compare treatments A, B, and C.) It is considered that this apparent anomaly can be explained by the fact that excess available nitrogen accentuates the effects of potash deficiency.

Observations During Growth.

No differences in treatments were observed till the fifth week after planting, when "leaf scorch" or indications of potash deficiency appeared in the three treatments not receiving sulphate of potash. The potash deficiency symptoms were most severe with superphosphate and sulphate of ammonia without potash, less severe with blood and bone and no potash and slight with no fertiliser.

Between the seventh and eleventh weeks after planting, it was observed that the two treatments containing blood and bone plus potash (treatments D and E) made very good growth while the comparative treatments containing artificial fertilisers (treatments F, G and H) were much inferior. During this period "whiptail" and Rhizoctonia made their appearance. Also a wilting, probably associated with a salt effect, aggravated by the concentrated application of soluble fertilisers, was more prevalent in the full rates of artificial fertiliser than in the half rates of artificial fertilisers. Many plants died at this stage.

[3] and [4]: See "Vegetable Growing," Bulletin 777, pages 62 and 72 for further information.

Up till the eleventh week, very little rain had fallen, but from then on heavy rain was experienced. By the twelfth week after planting, the treatments containing artificial fertilisers plus sulphate of potash had improved enormously and those treatments containing blood and bone plus sulphate of potash were no longer outstanding. At this stage, too, it first became evident that treatment H, which consisted of artificial fertilisers including potash plus a minor element mixture, exhibited no cases of the nutritional disorder "whiptail," while none of the other treatments had any consistent effect on the occurrence of "whiptail."

PLATE 2.

Cabbages from Fertiliser Experiment 5.—Showing the benefit of sulphate of potash at 2 cwts. per acre. *Left.* Cabbage receiving blood and bone and superphosphate only showing potash deficiency symptoms. Note leaf scorch, lighter green colour, and smaller size compared with cabbage on right. *Right.* Cabbage receiving superphosphate, nitrate of soda and sulphate of potash exhibiting healthy colour, smooth leaf and stronger growth.

By harvesting time all those treatments receiving sulphate of potash were practically equal in their effect on the growth of the crop. If anything, there was a slight advantage in favour of those treatments containing blood and bone plus potash.

It is probable that if a more suitable method of fertiliser placement had been adopted, to avoid fertiliser injury or "burn" in the early stages of growth, it would have eliminated the initial setback received by the artificial fertiliser treatments and these would have produced considerably better results at harvest time.

SOME NOTES ON THE TWO MAIN SOIL TYPES STUDIED.

(1) BLACK FRIABLE PEAT.

This soil is not naturally fertile and apart from the need for building up the fertility with fertilisers and manures, it presents other difficulties such as soil acidity or "sourness," a seasonal salt problem in certain patches, and apparently a tendency for some crops to suffer more or less severely from certain plant diseases. As is not uncommon in peats in other parts of the world, this soil seems to suffer from one or more minor element deficiencies.

The great advantage of this peat is its very moist nature and its ease of irrigation. The beds are quickly and easily irrigated by stopping the drains. However, this method of watering by ditches from the subsoil upwards (sub-irrigation), and having the water table so near the surface, favours surface salt concentration during the summer months when surface evaporation is high and rainfall is low.

It is significant that many growers considered that the problems associated with the acid peat country made it uneconomic to persevere with it, and they have consequently transferred their vegetable growing activities to the sand country, using sprinkler irrigation. They were fortunate in having an ample supply of good water at comparatively shallow depths, which could be lifted by electric pumps.

(2) LIGHT ORANGE DEEP SAND.

This soil originally grew tuart and stunted jarrah. It is naturally very infertile, but under sprinkler irrigation, suitable manurial treatment, and the annual application of about 5 to 10 tons per acre of suitable organic amendments or manures (such as animal manures, vegetable wastes, stable manure, compost, etc.) it can be made to produce high yields of good quality vegetables.

In this type of vegetable culture the sand acts mainly as a support for the plant. As the food and water requirements of the crop are supplied without depending on the fertility of the soil or the natural rainfall, it is, in effect, a large-scale application of the principles of water culture or hydroponics. The need for the application of some organic amendment can then be understood when we draw the analogy that the humus so produced performs many of the functions of the scientist when controlling his water culture solutions.

The sand country is preferred for a variety of crops for the metropolitan market by many growers. On the sand country the factors affecting growth conditions are more controllable, it warms up rapidly in the early spring, cultivation is easy, and in practice, fewer problems are encountered than on the peat. The cost of installing sprinkler irrigation is, of course, heavy. In the summer it is necessary to guard against the surface soil drying out and it seems the normal practice to turn on the sprinklers for at least one short period each day.

The Benefits of adequate Organic Matter in this Sandy Soil.

In the fertiliser experiments with carrots on "tuart" sand, the fertiliser treatments, because they followed along the lines of accepted practice, are superimposed upon a basal dressing of an organic amendment or manure, applied at a uniform undetermined rate, but judged to be up to 5 tons per acre. The no-fertiliser treatment, as shown in Table 3, gave a poor yield of small carrots, despite the residual fertiliser effect of liberal manurings from two crops grown on this ground since it was trenched the previous year.

However, the possible benefits to be derived from the adequate application of an organic amendment or manure to this type of sandy soil are as follows:—

1. The water holding capacity is improved by the addition of organic matter.

2. It guards against the possible lack of those plant foods not provided for by the application of artificial fertilisers.

3. Organic matter helps sandy soils to absorb and retain soluble fertilisers till they are drawn upon for the needs of the crop.

4. The physical properties of the sand are improved by the addition of organic matter.

5. If applied as a surface mulch it makes for the more efficient use of sprinkler water with less liability to leaching. Also better germination of fine seeds is often obtained in this soil which is prone to rapid drying out.

Even at the normal liberal rates of application, blood and bone is not an appreciable source of humus.

PLATE 3.

Leaves from healthy and potash deficient cabbages shown in Plate 2. *Left to right*: (1) Leaf from cabbage supplied with potash; (2) Leaf showing a yellowing extending backwards from the tip—no potash; (3) Leaf showing a marginal scorch. Note the brown and brittle dead tissue—no potash.

NITROGEN NUTRITION OF PLANTS AND THE BENEFIT OF SPLIT APPLICATIONS.

The crop needs a constant supply of nitrogen during its life to attain maximum growth. Under conditions of rainy weather or heavy irrigations it is often necessary to take special precautions to ensure that much of the soluble soil nitrate is not washed away from the feeding roots and thereby lost to the plant. The soluble nitrogenous artificial fertilisers, nitrate of soda and sulphate of ammonia, unlike superphosphate and potash fertilisers, are liable to be washed out of the feeding zone. It is therefore obvious that very soluble nitrogenous fertilisers are best applied in such quantities and at such time, so that they can maintain an adequate supply of nitrogen that can be readily taken up by the plant and losses by leaching minimised.

PLATE 4.

Normal and whiptail cauliflower plants. In experiment 7 a minor element mixture controlled whiptail in cauliflowers on this acidic ("sour") black friable peat.

(After Clayton.)

Heavy dressings of organic nitrogenous manures, such as blood and bone, at planting time, will usually ensure that the plant does not suffer from nitrogen starvation during its growth. Under the conditions of these experiments this object was also achieved by applying the soluble nitrogenous artificial fertiliser in three fractions, where necessary.

These principles of nitrogen nutrition are well illustrated in Experiment 4 (Table 3) with a winter crop of carrots on sand. In this instance applying all the nitrate of soda at planting time gave a yield almost as poor as no fertiliser at all, while applying the same amount of nitrate of soda in three fractions during growth almost doubled the yield.

The importance of the proper use of soluble nitrogenous fertilisers cannot be too strongly emphasised. Under the conditions of Experiment 4, the simple mistake of not applying the nitrate of soda in three split applications would have lowered the grower's financial return on a commercial crop of carrots by about £150 per acre.

It cannot be too strongly emphasised that under these conditions the simple mistake of not applying the nitrate of soda in three split applications would have lowered the grower's financial return on a commercial crop of carrots by about £150 per acre.

THE EFFECT OF FERTILISER PLACEMENT.

The method of applying the fertiliser in these experiments was the same as that used by the grower. Although it was recognised that this procedure may have acted to the detriment of the soluble artificial fertilisers, as compared with the less soluble blood and bone manure, no departure from accepted practice was made, because one of the aims of the experiments was to gather evidence, for or against, the average grower's dislike of artificial fertilisers.

In these experiments, for cabbages and cauliflowers on the peat, the fertiliser was concentrated in a hole dug a few inches away from the seedling plant, while for carrots on the sand, the fertiliser was broadcast on the surface between the rows and lightly cultivated in.

From fertiliser experiments with vegetables in other parts of the world, it is known that applications of soluble artificial fertilisers of over 10 cwt. per acre are liable, on many occasions, to produce severe injury to the germinating seed or the young seedling, and often to seriously reduce the yield. The injury is caused either when soluble fertilisers are in contact with the seed or seedling or when too strong a concentration of the fertiliser salts is present in the vicinity of the seed or seedling roots.

Harmful concentrations of fertiliser salts may be brought about by the movement of the soil moisture either up or down, and this aspect must be of importance in the wetting and drying of the peat soil we have studied. Also, if the soil moisture reaches a low level, the increased concentration of the soil solution in the vicinity of the seed or seedling root is liable to cause injury. Therefore, it can be seen that properly controlled sprinkler irrigation can be used to minimise the possibility of "fertiliser burn" on the sand country discussed.

Other methods that have been used to overcome fertiliser injury under certain conditions are as follows:—

1.—Delay the fertiliser application until the seedling has become well established and is more tolerant of high concentrations of soluble salts.

2.—Apply the fertiliser in a row and cultivate in, usually some time before planting the seed or seedling. This method can cause injury in some instances, as for instance, when the movement of the soil water is upwards, as during a dry spell.

3.—With some crops "band" placement of fertiliser has proved very successful in eliminating fertiliser injury. It consists of placing the fertiliser in bands a few inches to each side and a few inches below the level of the seed. In this case the movement of the soil water, either up or down, is not likely to bring high concentrations of fertiliser salts in contact with the young roots.

4.—Apply the muriate or sulphate of potash a short time (usually a fortnight) before sowing or planting out, apply the superphosphate at planting time, and apply the soluble nitrogenous fertiliser in split dressings.

However, it must be remembered that inefficiency and waste of fertiliser may result if the fertiliser is placed too far away from the growing plant. We should therefore aim for that placement of fertiliser which gives the most efficient results by reason of its close proximity to the feeding roots of the plant, without causing injury to the roots through harmful concentrations of the fertiliser salts.

CONCLUSIONS.

From the discussions and the results of the experiments, it is obvious that blood and bone manure can be replaced in vegetable growing under Perth metropolitan conditions, provided a suitable artificial fertiliser mixture is applied in a manner suitable for that particular crop and soil.

The two main obvious advantages of blood and bone over the improper application of artificial fertilisers under the conditions of these experiments, are that its nitrogen content is not readily washed out and that on the peat soil in the summer, during periods of low rainfall, it can be applied in liberal dressings without injury to the plant, provided potash is supplied where necessary. To sum up, blood and bone is a safe manure and needs little skill to obtain fairly satisfactory results. In skilful hands artificial fertilisers are capable of at least equal or even better crop yields.

The proper supply of nitrogen can also be provided with soluble nitrogenous artificial fertilisers by applying them in split dressings where necessary.

The different methods of applying soluble artificial fertilisers, or, as it is called, fertiliser placement, was not the subject of the experiments quoted. However, the principles underlying this very important aspect of the proper use of artificial fertilisers have been discussed and popular methods given for the alleviation of possible fertiliser injury.

The beneficial effects of minor elements have been observed on the acid peat, but further details have not yet been worked out.

In all but one experiment a substantial benefit was derived from the application of sulphate of potash at the rate of 2 cwts. per acre. Some growers believe that blood and bone is a complete manure. It is not, and its manurial effect is generally improved if superphosphate and potash are added.

ACKNOWLEDGMENTS.

These experiments were conducted as a co-operative effort by the Plant Nutrition and Potato Branches of the Department of Agriculture.

The plan of attack was decided upon as a result of discussions with L. J. H. Teakle (Plant Nutrition Officer) and E. T. Morgan (Officer in Charge of the Potato Branch). Valuable assistance was obtained from colleagues in both the

Plant Nutrition and Potato Branches, in the recording of observations, in the preparation and application of fertilisers, and in the harvesting of the experiments. The Statistical Branch of the Forests Department carried out the statistical examination of the data.

Thanks are due to the following market gardeners for allowing the experiments to be conducted on their properties, and for their valuable assistance and advice:—Messrs. J. Arbuckle and Sons, Balcatta; Mr. A. Pozzi, Osborne Park; and Mr. A. Guelfi, Osborne Park.

Fertilisers—Additional Registrations.

The December, 1944, issue of this Journal contains a list of the fertilisers registered for the current year, together with the minimum percentages of the fertilising ingredients. Additional registrations, with respective analyses, are shown in the following table.

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N_2) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail at Works or Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bone Dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
Florida Superphosphate 17%	57	Sickle	Cuming Smith & Mt. Lyell Farmers Fertiliser, Ltd.	....	....	....	....	13·00	2·50	1·50	17·00	....	....	†4 17 9
Mt. Lyell Superphosphate 17%	58	ML in diamond	do. do. do.	....	....	....	....	13·00	2·50	1·50	17·00	....	....	†4 17 9
Potato Manure "A2"	59	Sickle	do. do. do.	....	2·23	....	....	8·89	1·56	1·11	11·56	4·45	.....	†9 0 1
Potato Manure "A2"	60	ML in diamond	do. do. do.	....	2·23	....	....	8·89	1·56	1·11	11·56	4·45	....	†9 0 1
Potato Manure "A2"	61	C.S.M.L.	do. do. do.	....	2·23	....	....	8·89	1·56	1·11	11·56	4·45	....	†9 0 1
Superphosphate 17%	62	Cresco	Cresco Fertilisers (W.A.) Ltd.	....	....	....	....	13·00	2·50	1·50	17·00	....	....	†4 17 3
Sulphate of Ammonia	63	Elephant....	Cuming Smith & Mt. Lyell Farmers Fertiliser, Ltd.	....	20·50	....	....	....	....	....	....	....	....	†18 10 0
Blood and Bone	64	Pannifex	H. C. Pannifex & Co. Pty., Ltd.	....	....	6·25	....	....	13·50	....	13·50	....	....	*13 2 6

† Price on Rail at Works. * On Rails at Perth.

Agricultural Broadcasts.

The following programme of Agricultural Talks has been arranged for July-September quarter and will be broadcast from regional stations at 9.20 p each Thursday:—

Date.	Talk Prepared by :	Title.	Summary.
	I.—FARMERS IN A CHANGING WORLD.		
July 26	R. W. Brownlie, Secretary, Rural Reconstruction Commission	Value of technical knowledge to the farmer	A layman's appreciation o value of technical knowl in farming activities.
Aug. 23	C. A. Gardner, Government Botanist, Department of Agriculture	The Origins of Cultivated Plants II.	An account will be given o distribution and origins o more important cultiv plants.
Sept. 20	F. O. Grogan, Commonwealth Department of Commerce and Agriculture, Perth	Trends in Agricultural Marketing	This talk will indicate how keting of agricultural ducts has developed u present times, with emp on developments since W War I, and with commen the prospects for the post period.
	II.—TOPICAL ITEMS.		
July 5 Aug. 2 Aug. 30 Sept. 27	G. K. Baron-Hay, Under Secretary for Agriculture, will discuss current events in agriculture.		
	III.—FARMERS' FORUM.		
July 12 Aug. 9 Sept. 6	Discussion on subjects submitted by farmers is arranged by A. M. Stewart, Lecturer in Agriculture, University of W.A.		
	IV.—TECHNICAL TALKS.		
July 19	H. G. Elliott, Agrostologist, Department of Agriculture	Flax Growing ...	The latest knowledge on growing of flax.
Aug. 16	W. P. Cass Smith, Plant Pathologist, Department of Agriculture	Bean Mosaic ...	A discussion on some impo features of this virus di which has become a me to bean crops.
Sept. 13	C. F. H. Jenkins, Government Entomologist, Department of Agriculture	Grasshoppers ...	The importance of co-oper action in combating grasshopper pest will stressed, and recomme tions for control will be cribed.

By Authority: ROBERT H. MILLER, Government Printer, Perth.